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DISPATCH OF "THE RAILWAY GAZETTE" OVERSEAS

We would remind our readers that there are many overseas countries to which it is not permissible for private individuals to send printed journals and newspapers. THE RAILWAY GAZETTE *possesses the necessary permit and machinery for such dispatch, and any reader desirous of arranging for copies to be delivered to an agent or correspondent overseas should place the order with us together with the necessary delivery instructions.*

We would emphasise that copies addressed to places in Great Britain should not be re-directed to places overseas, as they are stopped under the provisions of Statutory Rules and Orders 1939, *No.* 1440

TO CALLERS AND TELEPHONERS

Consequent on the war and the blackout regulations, as an emergency measure to assist our staff in getting home before it is fully dark, our office hours (without a lunch interval) until Saturday, February 10, 1940, *are:—*

Mondays to Fridays - 9 *a.m. till* 3.15 *p.m.*
Saturdays - - - 9 *a.m. till* 1 *p.m.*

With the object of conserving paper by avoiding the return of unsold copies, readers are advised in the interests of all concerned to place a regular order for THE RAILWAY GAZETTE *either with their newsagent or direct with the Publisher*

Mr. Raymond Carpmael

THE retirement of Mr. Raymond Carpmael from the position of Chief Engineer of the Great Western Railway at the end of the year removes a popular figure from active railway service, but from our knowledge of Mr. Carpmael we have little doubt that the many institutions outside the railway to which he devoted so much of his spare time will not be altogether deprived of his valuable experience and advice. Apart from his associations in this country, Mr. Carpmael was well known in engineering circles abroad, particularly in France where he is a Member of the Société des Ingénieurs Civils. His early training, which took him as far afield as Germany and Mexico to supervise engineering works, doubtless gave him that broad outlook which all through his career has been an asset in enabling him to deal without any trace of insularity with all sections of his profession. It was probably his sympathy with the men who actually bring to fruition the plans of the technical engineer that made Mr. Carpmael so keen an advocate of education, particularly among the lower grades of the railway service with whom his special popularity was largely due to his approachability and sympathy. For four years he was President of the Permanent Way Institution, and during his visit as a member of the Pacific Locomotive Committee to India, he was instrumental in founding the first section of the institution in that country. Biographical details published on page 847 give merely the bare bones of a career which has left its mark on British railway engineering.

* * * *

Industrial Psychology

The nineteenth annual report of the National Institute of Industrial Psychology, just published, recalls that the institute was founded shortly after the last war, and it is hoped that the information accumulated and the experience gained will be used to the full during the present emergency, when methods of efficiency in all branches of industry are of vital importance. At a time when there are perforce many changes in industries working under wartime conditions, and when workers are required to adapt themselves at short notice to new and unusual tasks, the institute claims that its services should be more than ever welcome to employers and employed. The report describes briefly some of the problems with which the institute's investigators are accustomed to deal. Apart from the technique of vocational guidance and the testing of school children, industrial selection and training, clerical and office organisation, studies of heating, ventilation, and lighting, have all fallen within their scope. Particularly good results are reported in simplifying methods of work and in devising training schemes for new employees. Industrial lectures and training courses increased during the year. There was a notable increase in the number of young men sent to the institute by firms employing or proposing to employ them, and this and other advisory services available to employers must continue to be most valuable, especially under present conditions.

* * * *

Assam-Bengal Railway Organisation

The re-organisation of the traffic department of the Assam-Bengal Railway Company was mentioned by the Chairman (Mr. G. H. Ormerod) at the general meeting on December 5. He said that the re-organisation had come into operation during the year, the second stage being entered upon on January 9, when the functions of the running section of the Locomotive Department were transferred to the new Operating Department. It would be premature, he remarked, to make any comments on the results of this later development. Of the benefits of the establishment of the Commercial Department there

was no doubt. The Agent and General Manager reported that it was difficult to say how much of the increase in traffic in the southern section was due to the creation of that department, or how much was due to the headquarters organisation, but that in the northern section of the line—the Assam Valley—the new organisation had resulted in increased earnings amounting to Rs. 73,000 in tea traffic alone, and this figure should increase to Rs. 1,35,000 during the year 1939-40. The problem of motor competition was being given the most careful study by the Commercial Department which was, at present, experimenting with fares of 2 and 2½ pies a mile on two branches.

* * * *

Overseas Railway Traffics

A break in the upward rise of Central Argentine Railway traffics was shown in the 24th week of the current financial year, possibly due to rain. The Buenos Ayres Great Southern records a further gain of 151,000 pesos, however. Brazilian railway receipts in sterling have on the whole benefited from the improvement in exchange although receipts in currency are not so good as in the corresponding week of last year. The Entre Rios has a gain of 2,400 pesos in the 24th week, but the Argentine North Eastern is 2,300 down.

	No. of Week	Weekly Traffics	Inc. or Decrease	Aggregate Traffic	Inc. or Decrease
Buenos Ayres & Pacific* ..	23rd	1,316	— 65	26,764	+ 291
Buenos Ayres Great Southern* ..	24th	2,353	+ 151	46,187	— 947
Buenos Ayres Western* ..	24th	882	+ 8	16,693	+ 1,202
Central Argentine*	24th	1,569	— 126	43,224	+ 4,248
		£	£	£	£
Canadian Pacific	49th	664,800	+ 78,000	28,174,600	+1,525,600
Bombay, Baroda & Central India	36th	301,725	+ 47,400	6,004,950	+ 52,950

* Traffic figures in thousands of pesos.

Antofagasta Railway receipts in sterling have also benefited from improvement in the rates for remittances and the sterling decrease at the end of the 49th week was reduced to £54,970.

* * * *

Netherlands India State Railways in 1938

The financial results of the railways in Netherlands India for the year 1938, showed that on the Java lines passenger receipts rose from *f.* 8,259,695 to *f.* 8,859,428, and accounted for 31 per cent. of the total receipts. Goods traffic fell off, however, and the surplus declined from *f.* 7,572,458 to *f.* 5,287,857. In South Sumatra the working surplus fell to *f.* 903,392 from *f.* 1,136,034, but on the west coast lines there was an improvement, the surplus being *f.* 773,408 against *f.* 610,848 in 1937, chiefly attributable to increased coal traffic. There was a considerable increase in the passengers carried on the Java lines, 33,381,979 against 31,111,674 in 1937. Passenger-kilometres increased 5·28 per cent. Sugar forms the principal article of freight in Java, but the tonnage fell somewhat in 1938. The sugar industry has had many difficulties to contend with in the last few years. The railways have made great efforts to improve their services, introducing air-conditioning, better lighting, and streamlining. Lighting was at one time far from good in many vehicles, the few trains then running at night not justifying the cost of better equipment. This, however, no longer obtains.

* * * *

The Swiss Railway Museum

The Swiss Railway Museum, which was opened towards the end of 1916 and contains a number of interesting exhibits housed in a building in the Zurich goods station, has recently received some valuable additions to the mountain railway collection through members of the Riggenbach family, comprising plans, prints, and models, relating to the pioneer of rack railways in Europe, Nicholas Riggenbach. This gifted man, like Joseph Trick, was a native of Gebweiler, Alsace, and was born there in 1817, five years after Trick. Both men later became close associates of Emil Kessler, of the Esslingen locomotive and machinery works in Germany, from which many interesting designs of locomotive, including a number of the rail rack type, found their way to all parts of the world. Riggenbach worked at first in Paris and went as a fitter to Karlsruhe, Baden, in 1839. He took part in the first trial trips on the earliest Swiss line in 1847 and was for some time responsible for the locomotives on the Swiss Central Railway. His first patent for rack rail construction was obtained in 1863 and some seven years later his system was brought into practical use on the Rigi line. He died at Olten in Switzerland on July 25, 1899, at the age of 82.

* * * *

Track Distortion Experiments

The use of longer rails, and particularly of long lengths of welded rails, has given great prominence to the question of the resistance to deformation possessed by various types of permanent way construction. Numerous articles have appeared in the technical press containing elaborate calculations on the subject. An article in *Spoor- en Tramwegen* for September 2, 1939, by Mr. J. F. Deenik gives particulars of tests made on 12 metre (39 ft. 4 in.) lengths of complete track of three types. The first two were standard Netherlands track with cast-iron sole plates, one with sleepers set zig-zag, and the third a length of French track with the rails fixed to the sleepers direct with coach screws. The ends of each piece being effectively secured, power was applied sideways in the centre and various measurements taken. The best results were obtained with the Netherlands type track on zig-zag sleepers.

* * * *

Locomotives on Curves

Much attention has been given during the last few years on the Continent to the scientific study of the behaviour of locomotives and vehicles under various conditions of track, weight, speed, and the results of the experiments which have been made, notably in France and Germany, have in not a few cases overthrown some preconceived ideas. Very ingenious measuring apparatus has been constructed for this purpose, an example of which, together with its recorded results, was described in our issue of December 1. In the *Revue Générale des Chemins de fer* for February, 1939, Monsieur Lanos, a former officer of the French Eastern Railway, describes some remarkable experiments made on that line to investigate the nosing action of locomotives on curves. Sharp edged rings, attached to the wheels in different planes, registered on zinc sheet strips carried on flexible supports alongside the track, the rings being inked by pads in various colours. The article discusses, with the aid of mathematical analysis, the effects of superelevation, track irregularity, tyre form and thickness, and the influence of the tender. One of the author's conclusions is the importance of close accuracy in the maintenance of curve alignment and superelevation.

* * * *

Locomotive Inspection in America

A report presented at the annual meeting at Chicago last October of the Master Boiler Makers' Association, on the work of the American Bureau of Locomotive Inspection, by the Chief Inspector, Mr. J. M. Hall, provides some interesting information regarding the status and objects of the bureau. The necessity for the Boiler Inspection Law in the U.S.A. was brought about by the general practice of the railways of subordinating the carrying out of

needed repairs to the requirements of convenience. Practically all the large railways had inspection and repair rules, but these were generally considered to be merely expressions of desirable practice, and little if any attempt was made to apply substantial repairs if inconvenience and delay were caused thereby. As a consequence of this policy ineffective or temporary repairs were often applied, or locomotives having known defects were kept in service until failures occurred, many of which resulted in deaths or injuries. During the first year of operation of the law there were three boiler shell explosions in which 27 persons were killed and 41 injured, and 94 crown-plate and firebox failures resulting in 59 deaths and 168 cases of injury; the number of engines ordered out of service by the inspectors for necessary repairs was 3,377, and 3,591 boilers had to be strengthened. In 1938 crown-plate and firebox failures had been reduced to five cases, involving the death of five persons and injuries to three.

* * * *

Un Tour de Force

Among the methods of alleviating the tedium of enforced waits for train connections—all too frequent and all too long at present—is a machine known as a strength meter, upon an example of which we chanced recently at a small station. Briefly, by application of a simple tensile force and a penny, the traveller is given an indication of his strength. A list printed on the machine showed that athletes were rated highest at 500 units, aviators second with 495, and engine drivers third with 490. Passing engine drivers and aviators had obviously given full play to their knowledge of leverage, for the wall below the machine was covered with nail marks. Although solicitors were on the list with the unexpectedly low value of 300 units, and butchers with the unexpectedly low value of 380, the strength of the journalist was apparently beneath notice. However, to set up a record for the profession, we inserted our coin and grasped the bar. We did not succeed in pulling this barometer of strength off the wall, but modesty forbids us to say just what pull we did register. Suffice it that, by methods into which we need not enter here, our coin was returned to us. Only the whistle announcing the departure of the semi-express prevented us from endeavouring to enrich ourselves by gaining the coins of previous budding Sandows.

* * * *

More Standardisation

A few days ago the carriage in which we were travelling happened to pull up opposite a station bookstall, and we were surprised to observe that the official behind the counter was apparently the one from whom we had purchased our morning paper some twenty miles away. Bookstall managers, resourceful as they are known to be, presumably do not number among their powers that of flitting from stall to stall, so we were bound to conclude that we had been deceived by an external likeness. Indeed, on thinking the matter over, we can recall at least three such men who are as good as interchangeable. All have a hint of the academic in their appearance; all wear their hats at the post of duty as if they were insignia like the schoolmaster's mortarboard; and all possess the eye of the Ancient Mariner to transfix the wretch who tries to read a periodical on their counters without buying it. The *ensemble* is not unpleasing, and we regard the uniformity as a sturdy male reply to the rampant individualism flourishing in the platform tobacco kiosks which are often the bookstall's neighbours.

1939 in Retrospect

SINCE September 1, the Minister of Transport has exercised control of the four British main-line railways (G.W.R., L.M.S.R., L.N.E.R., and S.R.), the London Passenger Transport Board (including its road services), and the following minor railway companies:—East Kent Light Railways Company, Kent & East Sussex Light Railway Company, Kings Lynn Docks & Railway Company, Mersey Railway Company, and Shropshire & Montgomeryshire Light Railway Company. The step was taken before the declaration of war between Great Britain and Germany on September 3, under Regulation No. 69 of the Defence Regulations issued in pursuance of the Emergency Powers (Defence) Act, 1939, which received the Royal Assent on August 24, 1939. As in 1914, when an Order in Council of August 4, issued under Section 16 of the Regulation of the Forces Act, 1871, empowered the President of the Board of Trade to assume control of the railways, a committee was appointed to act as the agent of the Minister for the purpose of giving directions under the Order. This Railway Executive Committee consisted at first of Sir Ralph Wedgwood (formerly Chief General Manager, L.N.E.R.) as Chairman, and Sir James Milne (General Manager, G.W.R.), Mr. C. H. Newton (Chief General Manager, L.N.E.R.), Mr. Frank Pick (Vice-Chairman, London Transport), Mr. Gilbert S. Szlumper (General Manager, Southern Railway), and Sir William V. Wood (Vice-President, L.M.S.R.), with Mr. G. Cole Deacon (Secretary of the Railway Companies' Association) as Secretary. On September 25, however, Mr. Szlumper was appointed Director-General of Transportation & Movements at the War Office, and his place on the Executive Committee was taken by Mr. E. J. Missenden, who at the same time became General Manager of the Southern Railway (during Mr. Szlumper's absence) as well as retaining his office as Traffic Manager. The present Executive Committee has wider responsibilities than its predecessor of 1914, in that all the London Transport rail and road services now come within its purview, whereas in the last war London tubes, buses and trams were unaffected.

Train services were first affected by crisis conditions on September 1, when the requirements of evacuation necessitated some curtailment of main-line expresses and reductions on suburban routes between certain hours. In the next week there was a fairly complete return to normal on the L.N.E.R., L.M.S.R., and S.R., apart from the cancellation of high-speed luxury trains; the G.W.R. continued its evacuation service. On September 11 special spartan war-time schedules (prepared in expectation of early business disorganisation through air raids) were introduced by the L.N.E.R., L.M.S.R., and S.R.; these were improved somewhat in succeeding weeks. The G.W.R. began its war schedules on September 25, and was the first railway to issue a public timetable.

In the early part of the year the main-line railway companies were preoccupied with an impending crisis in their own affairs. Competition from road transport in conditions that were regarded as unfair to the railways inspired the launching in November, 1938, of a great railway publicity campaign appealing for a "square deal." At the same time a memorandum was submitted by the railways to the Minister of Transport proposing the repeal of the statutory regulations under which merchandise traffic is handled by the railways. The cardinal point was the urgency that the railways should have the freedom to charge suitable and appropriate rates for the goods they were liable to convey as common carriers, instead of being bound by a cumbersome system for the classification of merchandise which originated for the protection of traders over 100 years ago, when the railways were establishing

what was, in effect, a monopoly. Concurrently with the negotiations with the Minister of Transport, the railways stated their case to the public through a nation-wide publicity campaign conducted in the press and by means of posters, handbills, and many other forms of printed propaganda on railway premises. Two million copies were distributed of a free booklet entitled "Clear the Lines," in which the difficulties under which the railways laboured were explained in popular language. Proposals from the railways and other transport interests were heard by a special committee of the Transport Advisory Council set up on December 15, 1938, which in due course submitted a report on the position to the Minister of Transport.

This report was presented to the Minister on April 4, 1939, and published on May 19. It conceded the desirability of repealing the existing statutory control of railway rates, but recommended in the interests of traders that they should have the right of appeal to the Railway Rates Tribunal if the rates fixed by the companies themselves were not considered reasonable. Rate adjustments, it was recommended, should be the subject of discussion between representatives of the railways, and of trade and industry, at regular voluntary meetings. The report also approved the steps already taken by the railways and road interests to make voluntary agreements between themselves on rates for the transport of goods, either in general or in particular cases. For this purpose a Road & Rail Central Conference was set up and first met on April 12, 1939. It created 12 regional committees, all of which were in operation by August 1. The general opinion on the report and its recommendations was that it went further towards a general co-ordination of transport than had been contemplated by the railways in formulating their appeal, and that legislation of a novel kind would be necessary to implement it. A further publicity campaign urging the importance of swift government action to put the proposals into effect was begun by the railways in the press after publication of the report, but the rapidly deteriorating international situation naturally deferred any such action.

While the "square deal" campaign was inspired by declining freight traffic, the railways were also concerned for their revenue from passenger fares in the London suburban area. The four main lines and the London Passenger Transport Board therefore appealed to the Railway Rates Tribunal for its sanction to a 5 per cent. increase in passenger fares in the area concerned. The tribunal began to consider the appeal and the objections raised against it on March 20, 1939, and on May 24 issued a written judgment granting without reservation the application of the companies and the board. The revised fares came into force on June 11. As far as London Transport was concerned, the increases affected sections jointly owned by the board and the main-line companies, and certain parts of main-line routes over which the board's trains operate. In some cases the revision actually involved the lowering of fares owing to the removal of some anomalies in charging.

In January the London Midland & Scottish Railway sent one of its Coronation Scot train sets and streamlined locomotive to the U.S.A. for exhibition at the New York World's Fair. The vehicles were one of three sets being constructed at Derby for the Coronation Scot service, differing in certain mechanical and decorative features from the coaches with which the train was placed in service in 1937. Engine and carriages were painted L.M.S.R. red with gold lines, instead of the blue and silver finish at first adopted. A first class sleeping car was also included in the exhibition train, although not a part of the ordinary Coronation Scot formation. On arrival in the U.S.A., the train ran under its own power from Baltimore to Chicago and New York, calling at many American cities *en route*. In view of the outbreak of war, the train has been stored at Baltimore.

The first day of 1939 saw the conversion to electric working of another section of the Southern Railway, namely, the lines from Virginia Water to Reading, Ascot to Ash Vale junction, Frimley junction to Pirbright junction, and Guildford to Aldershot North junction—43 route-miles in all. By this scheme an increase of about 80 per cent. in service frequency was attained at the stations concerned, and journey times from London were reduced by some ten minutes. Another big electrification scheme was inaugurated by the Southern Railway on July 2, when electric working was extended from Swanley junction to Gillingham, from Otford junction to Maidstone East, from Gravesend to Rochester, and from Strood to Maidstone, totalling 53 route-miles. Considerable improvements were effected in the speed and frequency of service to Maidstone, Chatham, and other Medway towns. In addition to these conversions to electric traction of lines previously steam operated, the Southern Railway on May 28 opened a further portion of its newly-built electric line from Motspur Park to Chessington, which had been opened as far as Tolworth in 1938 and was extended to Chessington South on the date above mentioned. In 1939, also, there was completed the first of the new works undertaken under the London area £45 million new works programme of London Transport, the L.N.E.R., and the G.W.R. This was the extension of the Northern Line in tube from Archway station (formerly named Highgate) to East Finchley on the L.N.E.R.; the first public passenger trains ran on this section on July 3. This is part of the North London section of the scheme, undertaken jointly by the L.N.E.R. and London Transport, which will eventually permit through running of electric trains between the Northern Line tube of London Transport and the L.N.E.R. branches to Edgware and New Barnet. The new tube link between Baker Street and Finchley Road was brought into service on November 20, enabling Bakerloo Line trains to be projected to Stanmore.

As from June 25, 1939, working at the Victoria terminus of the Southern Railway has been controlled entirely by colour-light signals and electrically-operated points. A 225-lever all-electric frame was installed in a new signal box at the Central Section side of the station, and operates 90 pairs of points and 145 signals, concentrating the work formerly performed in three mechanical boxes. On the Eastern side of the station points and semaphore signals worked by electricity already existed, and much of the existing equipment could be modified to suit the new conditions. Another important safety development occurred in Scotland, when on August 13 some sets of automatic train control apparatus were brought into use on the Edinburgh—Glasgow (*via* Falkirk) main line of the L.N.E.R. They had been installed in consequence of recommendations contained in the Ministry of Transport report on the accident at Castlecary on December 10, 1937, and the whole of the Edinburgh—Glasgow route is being so equipped. The equipment is of the Hudd magnetic-inductive type, already adopted on the L.M.S.R. between London and Shoeburyness.

At the beginning of the year claims for shorter hours and improvements in rates of pay and conditions of service were submitted by the three railway trade unions to the Railway Staff National Tribunal, which heard the applications on January 24-31. The claims of the Associated Society of Locomotive Engineers & Firemen, and the Railway Clerks' Association were rejected in their entirety, but two awards were made in favour of the National Union of Railwaymen. This union's foremost claim, for a minimum weekly wage of 50s. for all adult

conciliation grade workers, was not conceded, but the tribunal agreed to a minimum of three instead of two hours' payment at the Sunday rate for each time of signing on duty on Sundays (the union had claimed four hours' payment); and made some adjustments regarding the spreading over of hours of work. The findings of the tribunal were embodied in its Decision No. 5, which was rejected by the A.S.L.E.F. and the N.U.R., both unions deciding to continue their previous demands, although the N.U.R. now concentrated upon the 50s. minimum. The Railway Clerks' Association accepted the decision, but supported the N.U.R. claim. As the railway companies declined its demands, the A.S.L.E.F. decided to call a strike of its members at midnight on August 26, but this was called off on account of the gravity by that date of the international situation. The claims of the A.S.L.E.F. and the N.U.R., together with a claim of the Railway Clerks' Association regarding payment for night work and free nights in the course of continuous night duty, were then referred to the Railway Staff National Tribunal, which began its hearing on September 19 and continued it on September 20. In the meanwhile, on July 28, the general managers of the four main-line railway companies informed the three railway trade unions that they had decided to increase the minimum rate of pay for adult male conciliation staff from 43s. to 45s. a week as from the beginning of the first full pay period after July 29. The findings of the tribunal (Decision No. 6) were given on October 18. They did not concede any claim in full, with the exception of that of the Railway Clerks' Association, and all were unanimous except those relating to the 50s. minimum wage claim of the N.U.R. In this case a majority finding (of the Chairman, Sir Arthur Salter, and the late Mr. H. J. May) recommended a minimum weekly rate for men of 50s. in London, 48s. in industrial areas, and 47s. in rural areas; and for women 38s. in London, 36s. 6d. in industrial areas, and 35s. in rural areas. To locomotive men the tribunal unanimously awarded an increase of a shilling a day in the minimum rate of drivers and motormen, making it 13s. a day. It also made important alterations in the minimum payments for Sunday duty performed by conciliation grades and salaried staff. The majority findings and the unanimous findings have now been accepted by the railway companies and by all three trade unions. It is estimated that their acceptance will, with other consequential increase, involve an addition of £1,000,000 a year to the salaries and wages bill of the companies. The new rates apply as from the first full pay period after October 28.

Ever since the crisis of September, 1938, the railways had been carrying on with the emergency measures then instituted, and to assist in the essential protective works a loan of £4,000,000 was voted by the Government. Apart from strengthening of buildings and other property at vital points, colour-light signals have been hooded to obscure them from aircraft flying overhead, and locomotives are provided with tarpaulins to blackout the glare from the fire. Staff on all systems have been trained in A.R.P. measures, and on the L.M.S.R. and Southern Railway special trains were equipped as travelling schools to tour the two systems. All four railways are providing ambulance trains and arranging special timetables for their operation. To ensure an adequate supply of locomotives in an emergency, types that would normally have been broken up on completion of their actuarial life have, on withdrawal from traffic, been preserved. Vast transport enterprises undertaken by the railways have been the distribution of steel shelters and components for their erection, the evacuation of vulnerable areas, and transport of troops and their equipment to the ports of embarkation. Subsequent events are too recent to need recapitulation, and the pictorial retrospect at pages 833 to 846 should assist in recalling to mind some further outstanding events of a notable year.

Letter to the Editor

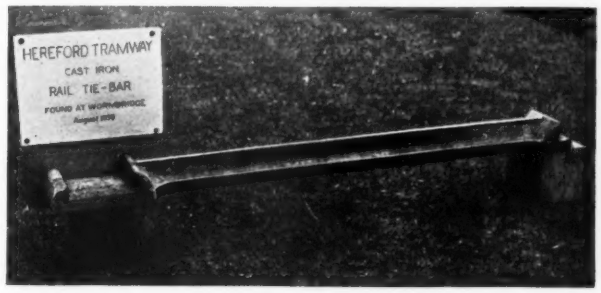
(The Editor is not responsible for the opinions of correspondents)

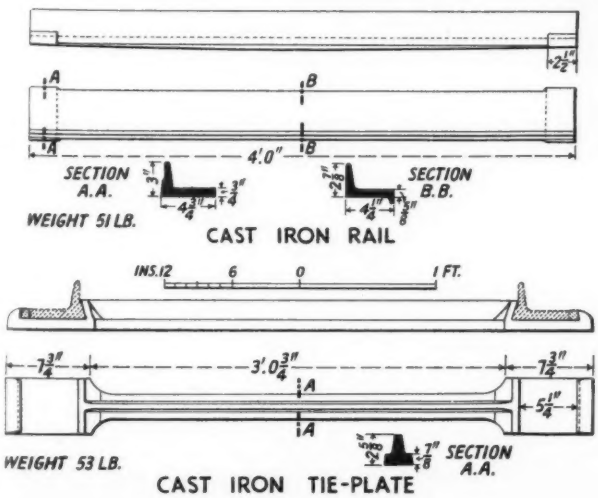
The Old Hereford Tramroad

High Street, Eardisley,
December 17

To the Editor of The Railway Gazette

Sir,—In your issue of August 11 last you published a letter from me about some permanent way finds which have resulted from my efforts in unearthing details of the old tramroads between Abergavenny and Hereford. You also reproduced a photograph of a stone sleeper having a spade-shaped indentation which I was then unable to explain with certainty. In collaboration with Mr. E. H. Morris, I have now been fortunate enough to find in a stream under the tramroad the nearly perfect cast-iron tie sleeper and chairs, cast in one piece, of which I enclose a photograph. The accompanying dimensioned drawings (prepared by Mr. Morris) show that the chair of the tie plate corresponds with the indentation in the stone sleeper block.





This tramroad was formed under the Hereford Railway Act of 1826 and was therefore comparatively late for tramroad or plateway construction. Unlike the practice with earlier lines, the stone sleepers were not drilled, and, as I mentioned before, ballast consisting of fine sand and gravel from the banks of the River Wye was used.

Yours faithfully,

FRANCIS B. ELLISON, CAPT.,
Architect and Surveyor

PUBLICATIONS RECEIVED

A Handbook of Home-Grown Timbers, and a Handbook of Empire Timbers. London: H.M. Stationery Office, W.C.2. Price: 2s. net for the first volume and 3s. 6d. net for the second volume.—One of the specialised avenues of railway working, particularly in this country, is the study of woods—for rolling stock, sleepers, and miscellaneous purposes—and handy summaries of the types, properties and treatments of British and Empire timbers, such as those compiled by the Department of Scientific and Industrial Research for inclusion in these two volumes, will not come amiss. The first book covers 26 hardwoods and 9 softwoods, and the Empire book 79 hardwoods and 17 soft woods. In each volume there is a preliminary section covering the strength properties of timber in general, and giving attention to the relative energy-absorbing qualities.

Firthag Steel.—Two attractively produced leaflets have recently been issued by Thos. Firth & John Brown Limited, of Sheffield, describing Firthag steel, a medium carbon chromium-manganese steel originally made by the firm for parts of agricultural machinery. It solves the problem of a steel which will give better results than a straight carbon steel and yet not be so expensive as a nickel or a nickel-chrome steel. The use of this steel is spreading to the makers of machine tools, textile machinery, and crushing and grinding machinery; and railway engineers and the general engineering trades are now among users. In fact, there seems to be no limit to the variety of purposes to which Firthag steel, when suitably heat-treated, can be put.

Lighting Fittings.—Modern equipment for general and local lighting for industrial purposes is described and priced in an 80-page book (F.4 Section, 10th edition) issued by the General Electric Co. Ltd., of Magnet House, Kingsway, London, W.C.2.

Earth Testing.—Another Evershed & Vignoles booklet, No. 202, deals with earth testing, and within 34 pages forms a useful primer on the subject, giving information on regulations, the characteristics and measurement of earth resistance, the types of electrode in use, and practical testing points.

THE SCRAP HEAP

HORSE TRACTION AT WICKLOW

The *Daily Express* of March 11, 1867, announced "It is understood that the inconvenient plan of horsing passengers on the Dublin & Wicklow Railway from Wicklow Junction to that town is to be abandoned, the train passing into the station and out again as of old." In the *Irish Times* of April 2, 1867, it is stated "For the future, until further notice, all trains to and from Wicklow will be driven right into Wicklow station, and not shunted by horses as formerly."

* * *

It is possible to create, haphazard, any kind of public office, without bothering in the least about what its duties are going to be or having any idea what to do with it. Or, again, an admitted sinecure may be created. But after a time the office in question will be sending and receiving letters, keeping registers, and piling up files. It comes alive, prospers, and keeps everyone in its neighbourhood busy. In a year it becomes indispensable. Such is the characteristic and sublime spirit of bureaucracy, which is eminently creative and endowed with a great deal of vitality. Give me a sheet of paper, it says, and I'll soon make whole archives for you.—*From "Spaniards' Way," by Vittorio G. Rossi.*

* * *

Dogs which collect for railway charities are well known in England and many delightful stories have been told of canine attachment to particular railway stations and fondness for railway travel. The United States of America, however, claims the distinction of the most travelled dog in the world for one *Owney*. This little animal crept into a post office at Albany, N.Y., one bitterly cold winter's night, and as the clerks were busy and did not notice him, he found some sacks and curling up on them went to sleep. Next morning his pleading eyes and generally pathetic appearance touched the men's hearts and they decided to adopt him. Naturally the dog grew deeply attached to the men and he took a great interest in their work, particularly in the sacks of mail. Often he accompanied these to one of the stations. Later he travelled about with the sacks and people hearing of his trips used to attach a label to his collar to show how far he had travelled. In time the weight became uncomfortable and a special harness was made for him to carry these relics in comfort. As time went on he widened his field sufficiently to board a ship bound for Japan. *Owney* attracted so much attention in Japan that he was decorated with a medal by the Emperor. After extensive travelling about the East, he was put on a ship sailing to New York and on arrival there he sought out a west-bound mail car and set out for Tacoma, Wash., having completed the journey round the world in 132 days. At a dog show in San Francisco, *Owney* was given a silver medal as the most widely-travelled dog in the world. Unfortunately he grew ill-tempered with age and in August, 1897, it was deemed necessary to destroy him as he had severely injured a clerk in Toledo post office. *Owney's* body was stuffed and may be seen in the Smithsonian Museum at Washington, complete with the tags, labels, and harness he wore so proudly in life.

KINGS CROSS,
DECEMBER 23RD. 1899.
The Great Northern Railway Company's
Chief Goods Managers' Staff
send Best Wishes for a Happy Christmas and a Prosperous
New Year.

Reproduction of a coloured Christmas card issued by the Chief Goods Manager's Office of the Great Northern Railway exactly 40 years ago

OVERSEAS RAILWAY AFFAIRS

(From our special correspondents)

ARGENTINA

No Fusion of C.A.R. and B.A.P.R.

The rumours of a possible fusion or working agreement between the Central Argentine and the Buenos Ayres Pacific Companies have been dispelled in statements to the press by the respective general managers, Mr. D. M. MacRae and Mr. M. F. Ryan, on their return to Buenos Aires from Europe.

Mr. MacRae said that the feasibility of extending co-operation between the two companies had been exhaustively examined in London recently, and an arrangement had been come to concerning the specific directions (mainly on the operating side) in which it could be developed. The difficulties in the way of a more comprehensive scheme were (*a*) geographical—the ramifications of the two systems being entirely divergent—and (*b*) the dissimilarity in the nature of traffics. It was considered that whilst existing conditions prevailed the two railways should remain under separate managements, but with such co-operation as would improve methods of working or achieve economies.

Mr. Ryan confirmed the decision of the boards that there was nothing to be gained by combining the two administrations, though the existing co-operation should be continued, so that each railway would benefit from the full "brain power" of the other; any new operating methods, for example, devised by the one administration would be automatically passed on to the other. The question of overlapping had already been dealt with by close working at junction points such as Junin and Villa Maria.

Mr. Ryan referred to the probable effect of the war on the Argentine railways, in making it difficult to obtain materials and equipment from the United Kingdom, in which case they would have to seek other sources of supply. There was, however, no question of British export trade being ignored.

Turning to the subject of exchange, Mr. Ryan said that if, because of the depreciation of the pound, the railways secured a favourable rate of exchange from the Argentine Government, they might get outside the zone of wage deductions. In conclusion, Mr. Ryan stated that, in view of the situation created by the war, the Government was exempting the companies from carrying out any new works except those strictly essential, a relief for which the railways were most grateful.

Transfer of Transandine Railway

The final formalities in connection with the purchase by the Argentine Government of the Transandine Railway were concluded at Mendoza in October, and the line was finally incorporated in the State Railway system.

Priority for Fuel Transport

A memorandum from the National Railway Board to the Ministry of Public Works says that the possible scarcity of imported fuel because of the war necessitates the development of the country's natural resources of coal, wood and oil. In this connection the railways and other public services are to have preferential treatment for the transportation of their fuel.

Decrease in Grain Sowings

The second estimate, issued by the Ministry of Agriculture, of the area sown with cereals and linseed this year indicates a decrease of 739,000 hectares (1,847,000 acres) or 5·19 per cent., as compared with last year. The figures relating to the four principal crops are as follow:—

	Hectares	Acres
Wheat.. ..	7,200,000	18,000,000
Linseed ..	3,100,000	7,750,000
Oats	1,400,000	3,500,000
Barley.. ..	900,000	2,250,000

Exceptionally heavy rain fell in the first fortnight of October, especially in the Provinces of Buenos Aires, Santa Fe, and Cordoba, resulting in damage to the growing crops. The railways fortunately escaped serious damage.

Reduced Sugar Freights

The State Railways administration has been authorised by the Government to quote specially reduced tariffs for the transport of sugar for export over various sections of its system in order to facilitate the marketing of the large surplus stocks remaining over from the 1938-39 harvest. The new tariffs are designed to favour the sugar factories situated in the Provinces of Tucuman, Salta, and Jujuy, served by the Central North Argentine and Cordoba Central Railways.

Engineering and other Meetings

At a meeting of the Buenos Aires Association of the Institution of Civil Engineers on October 26, Mr. E. Pilditch lectured on damage caused by floods of the River Mendoza, and the re-survey of the Argentine Transandine Railway. After sketching the history of the railway from 1874, when the first contract was signed, to 1910, when through traffic between Argentina and Chile was inaugurated, the lecturer described the damage done by the floods of January, 1934, and the efforts made to discover the source of the unprecedented avalanche of water. This problem was of vital importance not only to the railway but also to the Irrigation Department, to provincial authorities and to the electric light and power company, whose hydro-electric generating plant at Cacheuta had been seriously damaged and put out of operation.

A paper on "National Aspects of Transport" was read by Mr. G. F Bilbrough to the Argentine and River Plate Centre of the Institute of Transport on October 27.

NICARAGUA

Railways Nationalised

The National Railways of the Republic of Nicaragua, under a Presidential Order of November 7, are to be completely nationalised. The system was originally controlled by an American undertaking, incorporated in the State of Maine in 1912, 51 per cent. of the stock of which was owned in New York and the remainder by the Nicaraguan Government. For some time past the whole of the stock has been owned by the Government, and the directorate was moved to Nicaragua two years ago. Under the new order the company will disappear and the railways will be completely nationalised.

UNITED STATES

New Delaware & Hudson Coaches

The Delaware & Hudson Railroad recently received a number of new lightweight, streamlined and air-conditioned passenger coaches intended for service on the Laurentian fast, daylight train between Montreal and New York. The new coaches seat 76 passengers in greater comfort than hitherto. They are of all-welded construction, insulated against noise, and with double windows and dehydrated units to prevent fogging. The cars are equipped with reclining and rotating seats.

WESTERN AUSTRALIA

Freight Rate Increases

In order to offset the heavy increase in expenditure [recorded in our issue of November 10—Ed., *R.G.*] due to basic wage increases, improved conditions granted by the new industrial awards of the State Arbitration Court, and higher cost of fuel, "Miscellaneous" and most "C" class freight rates were raised by 10 per cent. from October 1. These increases are expected to yield additional sums of £25,000 and £12,000 a year, respectively. With other sources of increased revenues, the total increase in receipts is expected to be about £50,000 per annum.

The net financial results for the first quarter of the current fiscal year show an improvement of £28,000 over the corresponding period in the last year. Earnings were up by £29,000 and expenditure—due to economies noted below—was £5,000 lower, but an increase in the interest charges more than absorbed the saving in expenditure.

Economies are being effected by a curtailment of passenger train services, particularly on Sundays, but no reduction of staff has been made, as this would only cause unemployment at the expense of the State. Vacancies due to

retirements and deaths have, however, not been filled to date, rearrangements of duties making this possible.

At present revenue prospects are bright for the next few months, and additional traffic, coupled with a strict watch on expenditure and the effect of the freight increases operating from October 1, should result in a continuation of the improvement shown for the first three months of the year. The war, however, now makes it impossible to forecast future results with accuracy.

DENMARK

Memorial to Railwaymen

On October 29 a memorial was unveiled in Fredericia to commemorate all servants of the State Railways and their constituent companies, who have met their deaths in the course of duty. The memorial comprises a central stone monument flanked by two smaller stones, the whole being again surrounded by many smaller gravestones arranged in a small grove. The smaller stones bear the names of each of the 385 railway servants who have lost their lives during the present century. The two stones flanking the central monument commemorate, respectively, all those railway servants killed before the beginning of this century, and all those who, though they were not servants of the railway, met their deaths while engaged on railway works. The central stone bears a short inscription, surmounted by the crest of the State Railways.

SWITZERLAND

New Works in 1940

Further particulars of the Federal Railways budget for 1940, briefly referred to in the November 17 issue of THE RAILWAY GAZETTE, are now available. Important works provided for in part in the previous budget, and which are to be continued, include :—

Extensions and alterations at Geneva, Neuchâtel and Basle stations.

Berne-Wilerfeld four-track deviation.

Doubling the Sisikon-Fluelen and Taverne-Lugano sections of the Gotthard route.

Doubling the Zurich-Sargans line between Pfäffikon and Lachen.

Deviations of the same line between Mühlehorn and Flums (in connection with the construction of a new road), with provision for doubling this section.

Electrification of the metre-gauge Brünig line (Lucerne-Interlaken).

New works to be undertaken are :—

First section of the connecting line between Cornavin and Eaux-Vives stations, Geneva (providing a new goods station in the industrial quarter of the town, near the location of the future Rhone port).

Construction of a line connecting the Muttenzerfeld marshalling yard, Basle, with the Delémont route (at present reached only from the Wolf yard, with reversal).

Track improvements at various points, to permit of higher speeds.

Modernising at numerous stations, particularly as regards signalling and telephones.

Further extensions of electric block working and of the automatic train control system.

A sum of fr. 10,100,000 is allocated to the purchase of rolling stock, including 4 lightweight electric motor-coaches or locomotives for high-speed trains, 11 electric shunting engines, 40 coaches, 8 vans, 150 goods wagons, and various service vehicles, also 3 coaches for the metre-gauge Brünig section. The following are to be scrapped during the year :—10 steam locomotives, 50 coaches, 30 vans, and 220 goods and service wagons. The Federal Railways will have in service at the end of 1940 : 506 electric, 359 steam and 3 other locomotives, 64 electric and diesel motor-coaches, railcars, and fixed sets, 145 light shunting engines, 3,523 coaches, 649 vans, and 16,104 goods wagons, not including metre-gauge stock.

PORTUGAL

The Beja Deviation

A technical commission, appointed by the General Direction of Railways, is studying the possibility of a deviation in the Algarve line, with the object of abolishing the detour which parallels the main line at the point of departure from Beja station, and which involves turning locomotives. A new line is under consideration which would avoid this and effect an appreciable saving in the schedule timing of express trains.

Length of Open Lines

According to the annual report of the Direction General of Railways, just issued, the total length of the railways in operation in Portugal at the end of 1938 was 3,581 km. (2,225 miles), of which 2,821 km. (1,753 miles) were of broad (5 ft. 6 in.) gauge. During the year the lines opened to working were, Mogadouro-Duas Igrejas, 32 km., the Oporto Circunvalation line, 19·8 km., and the short section between Boa Vista and Trindade.

SPAIN

Boards of Directors Dissolved

The boards of directors of the three principal Spanish railway companies, the Northern, Madrid-Zaragoza-Alicante, and the Western-Andaluces were ordered to be dissolved by the Law of May 8, 1939, which transferred the control of the railways to directing councils appointed by the Minister of Public Works in each case. An Order dated November 1, and published in the Madrid *Boletin Oficial* of November 10, provides that the boards of directors shall convoke extraordinary general meetings of the shareholders of each of the companies, in order to give account of their administration during the period prior to the date of the law. The meetings are to be held before April 1, 1940, after which the boards of directors will be considered to have been finally dissolved. A second Order provides for the dissolution, in a similar way, of the boards of all the undertakings subsidiary and affiliated to the three companies. This seems now to be the final chapter in the history of the independent control of the three principal privately-owned railways.

CHINA

European War Stops Work on Burma—Yunnan Railway

Due to the war in Europe and consequent difficulties in supply and transport, lack of materials is reported to have brought construction upon the Yunnan—Burma railway to a standstill. Other contributary causes to the cessation of work are said to be autumnal seasonal epidemics in Yunnan, and opposition to the railway by the wild tribes on the Burma—Yunnan frontier, who fear that its completion will bring an influx of Chinese immigrants from the interior of Yunnan.

Thoroughness of Chinese Demolition and Guerrillas

Despite the fact that the important junction of Hsuchow—where the Lung-Hai Railway intersects the Teintsin—Pukow line—was captured by the Japanese in May, 1938, the eastern section of the Lung-Hai line thence to Haichow and the terminal port of Lienyunkang, 224 km. in length, was not reopened for traffic under Japanese auspices until the end of this last October. This fact and also the recent reopening of the Kiukiang-Nanchang [reported in our issue of December 15, ED., *R.G.*] are remarkable testimonies to the thoroughness of the Chinese demolition and to the constant harassing of the Japanese by Chinese irregulars.

Chinese Still Working Chekiang-Kiangsi Railway

On the other hand, the Chekiang—Kiangsi Railway is still in operation by the Chinese from a point south of Hangchow to another south-east of Nanchang, though both Hangchow and Nanchang have been in Japanese hands for many months past. In fact, Hangchow was evacuated by the Chinese in December, 1937, but further effective advance by the Japanese was checked by the demolition of the great Chientang river bridge. During July, 1938, over 500 trains were run over this line. When, however, in March last, Nanchang was threatened, and later lost to the Japanese, the 500 km. of the line westward of that city were taken up and sent further west to make possible the construction of the strategic line from Hengchow to Kweilin, Nanning, and the French Indo-China frontier, and the Chuchow-Kweichow line. This had the effect not only of isolating the remaining portion of the Chekiang—Kiangsi Railway (Hangchow—Nanchang), but also of cutting it off from the Pinghsiang mines. The remaining section is, nevertheless, said to be earning $500,000 a month, which covers cost of operation, and it is significant that all its 30 locomotives and also the repair shops are still in service, and sections of line damaged by Japanese air raids are quickly repaired. These achievements are notable tributes to the tenacity, resource, and technical ability of Chinese railwaymen.

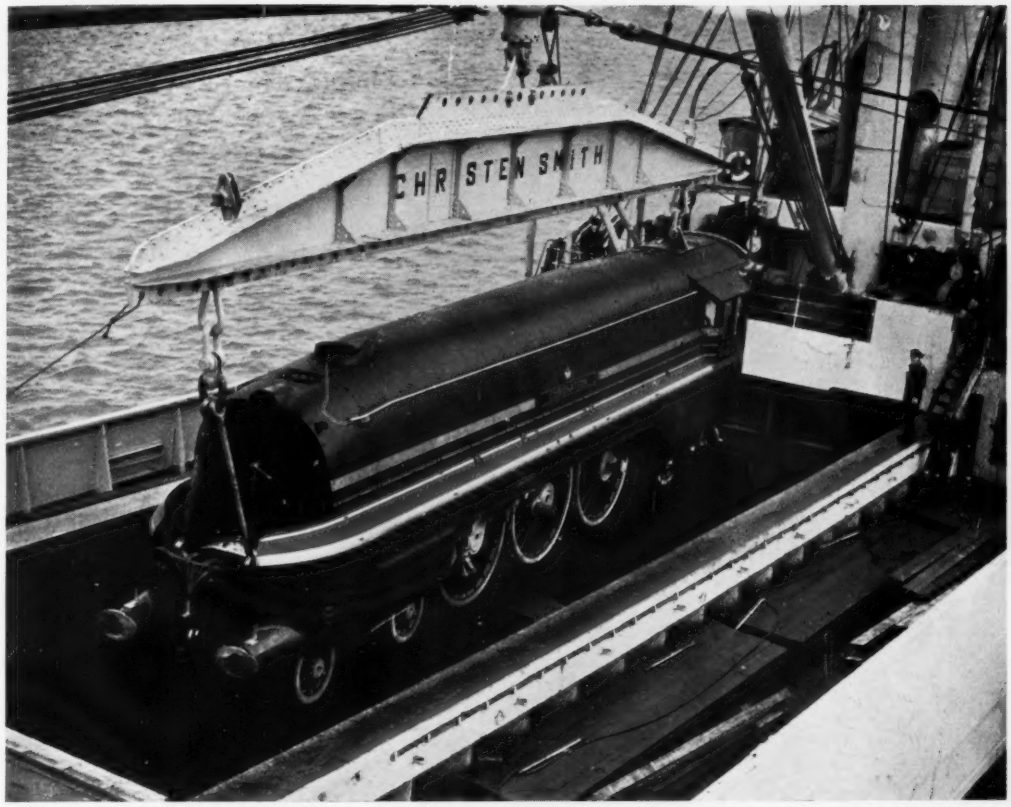
A Pictorial Retrospect of 1939

Lord Ashfield, Chairman of the London Passenger Transport Board, and Sir Ronald Matthews, Chairman of the London & North Eastern Railway, on the arrival of the first tube train between Archway (Highgate) and East Finchley on June 28. This short connecting line from the Northern tube to the L.N.E.R. Barnet and Edgware branches forms the first new line of the £45,000,000 new works and equipment programme of the London Passenger Transport Board and the main-line railways

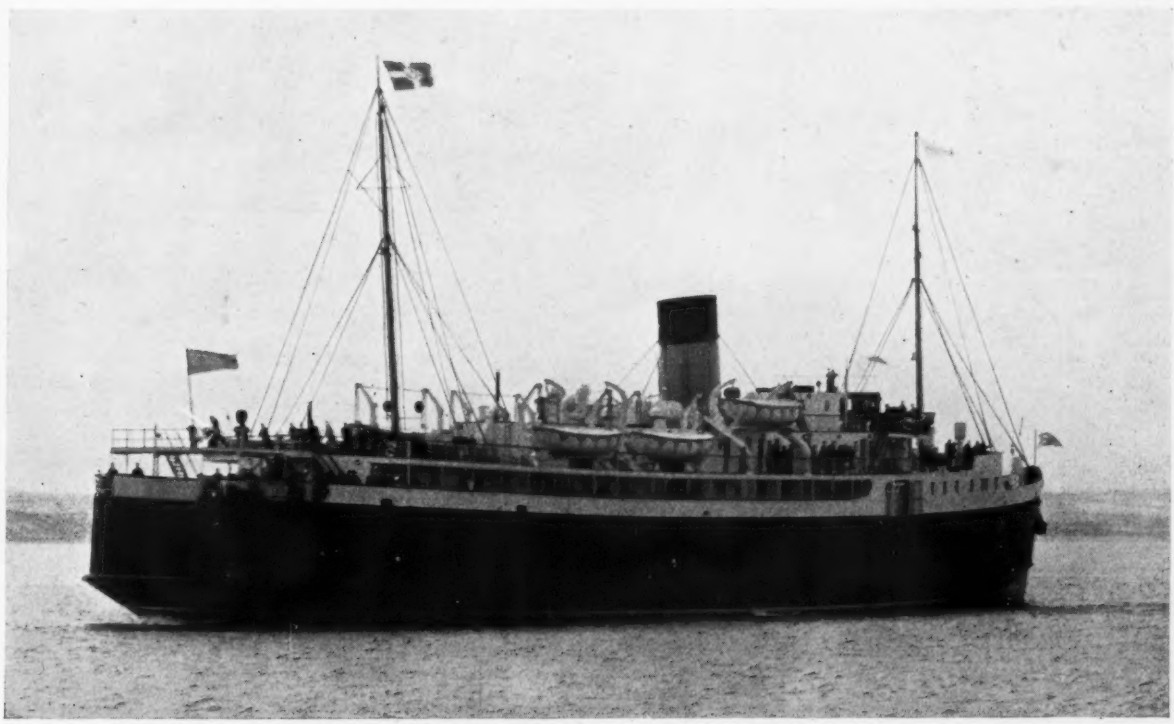
Metropolitan train hauled by electric locomotive crossing a Bakerloo Stanmore train at the new burrowing junction north of Wembley Park, L.P.T.B. Direct connection between the West End (via the Bakerloo tube) and Stanmore began on November 20

General view of the holiday camp erected jointly by the L.M.S.R. and Thos. Cook & Sons Ltd., at Prestatyn, North Wales, and opened by Lord Stamp on June 22

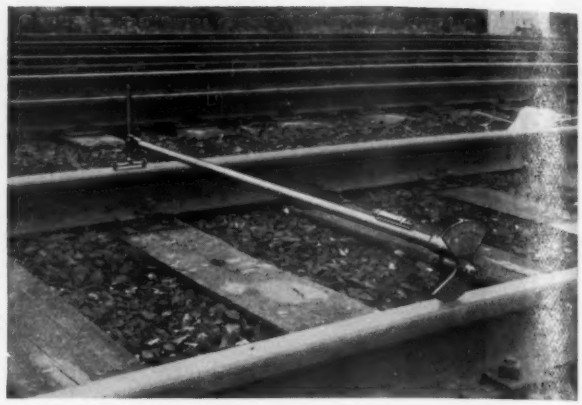
Improvements at King's Cross station, L.N.E.R. Departure platform barriers, with time of the Queen of Scots Pullman indicated on No. 10. Excursion and other special notices are posted on the boards seen between platform entrances



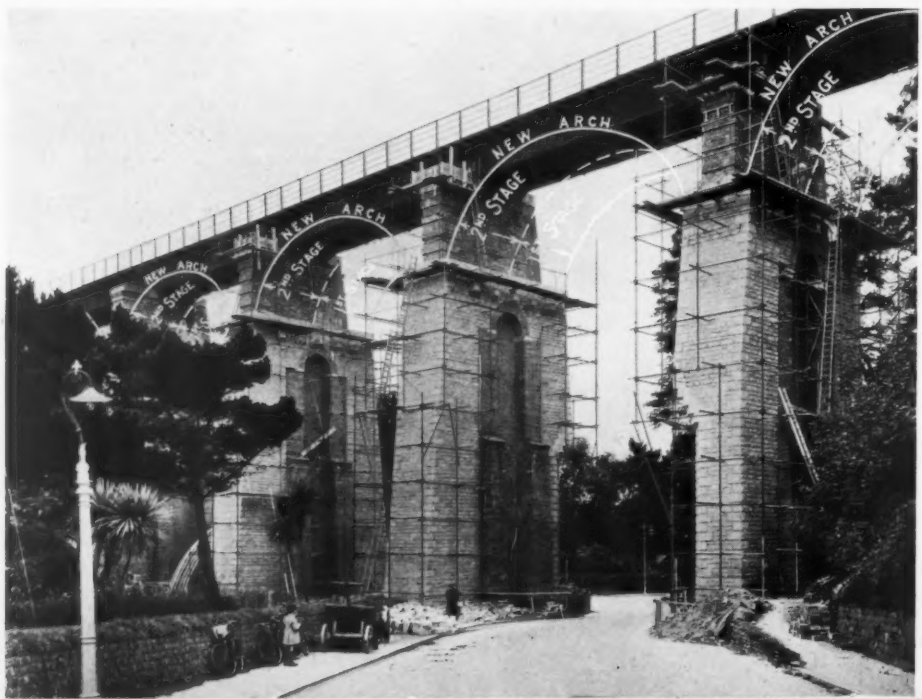
Lowering the L.M.S.R. locomotive "Coronation" into the hold of the "Belpamela" for its journey to the New York World's Fair. The front-end streamline casing has been removed to facilitate slinging



The "Princess Victoria," the new L.M.S.R. steamer for the Stranraer-Larne route, in service on July 8



Measured shovel packing on the L.M.S.R. Left: Spreading chippings under sleeper. Right: Abtus level transfer gauge



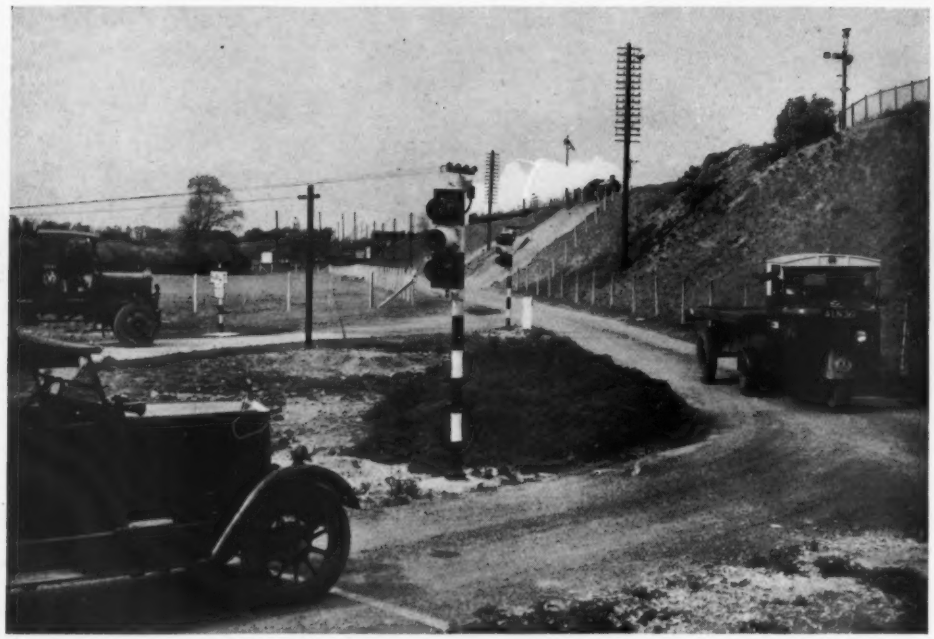
Left: General view of the Trenance viaduct, G.W.R., showing the stages of the reconstruction scheme, and the positions of the new arches; note also the chamfered and corbelled piers

Flat-bottom track on L.N.E.R. near Bishopbriggs. Elastic spike and clip and bolt fastenings (right), and (left) clip and bolt fastenings

Above : Special form of reinforced concrete platform roofing, dispensing with supporting pillars, at Chessington station on the Tolworth-Chessington extension, Southern Railway, opened on May 28

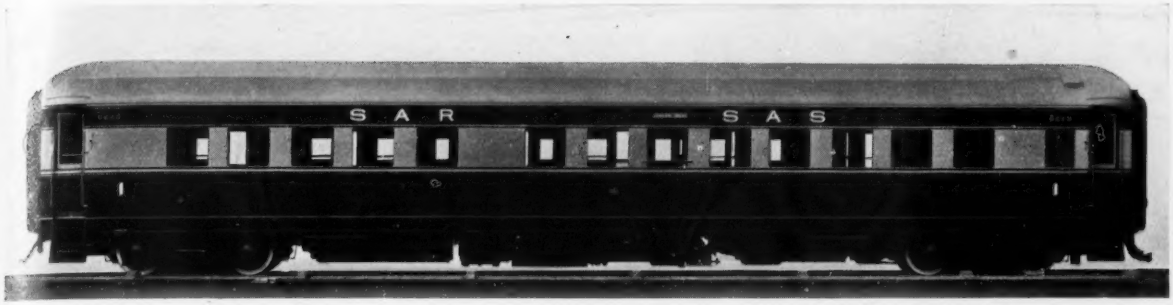
Right : Thermit-welded joint near Hildenborough, Southern Railway, where there are 120-ft. and 180-ft. rail lengths on the down main line

Below : Laying the lines in the cutting between Swanley junction and the new station, Southern Railway, preparatory to electrification extension



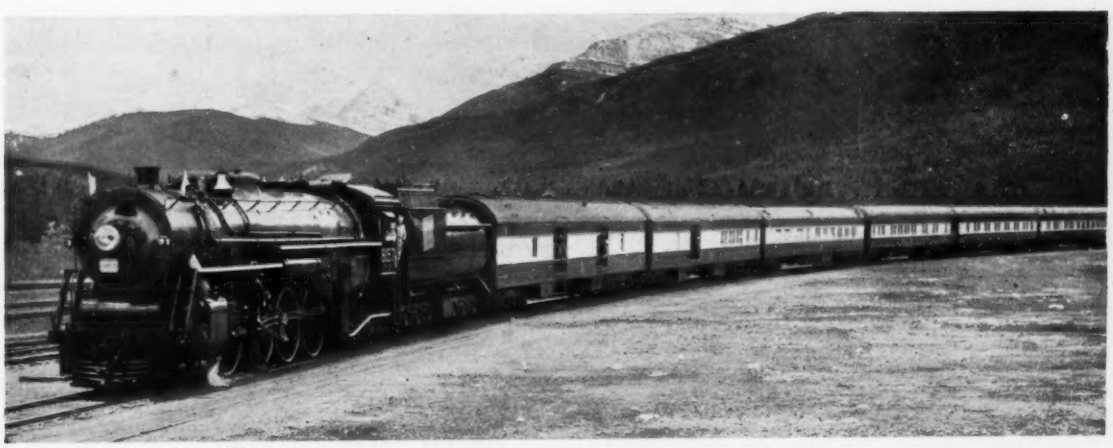
View on the Taplow training ground at the school for motor drivers laid out by the G.W.R. for recruits to the road motor staff

Interior of new Victoria Central signal box, showing 225-lever all-electric locking frame, illuminated diagrams in triplicate, and train describers. The entire resignalling of this station in June completed the modernisation of the signalling equipment at the Southern Railway's London termini

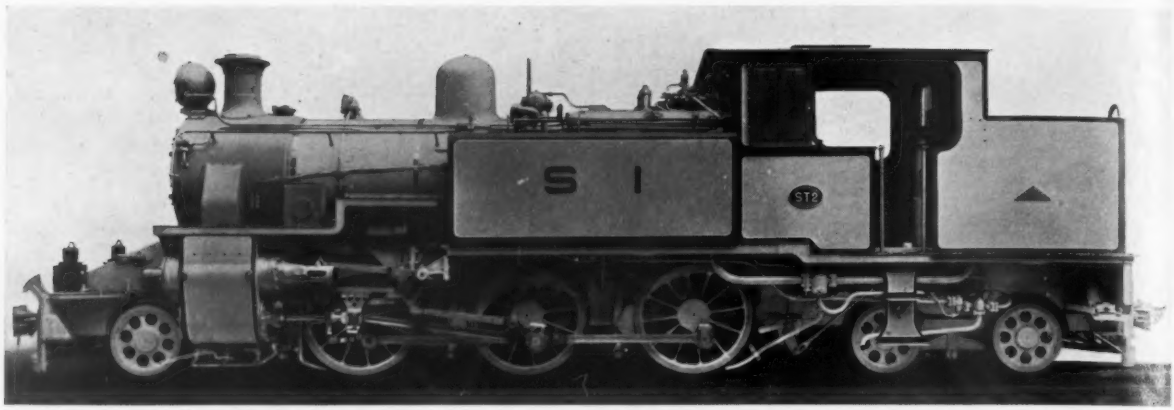


Exterior view of new Metro-Cammell steel air-conditioned coach for the South African Railways & Harbours

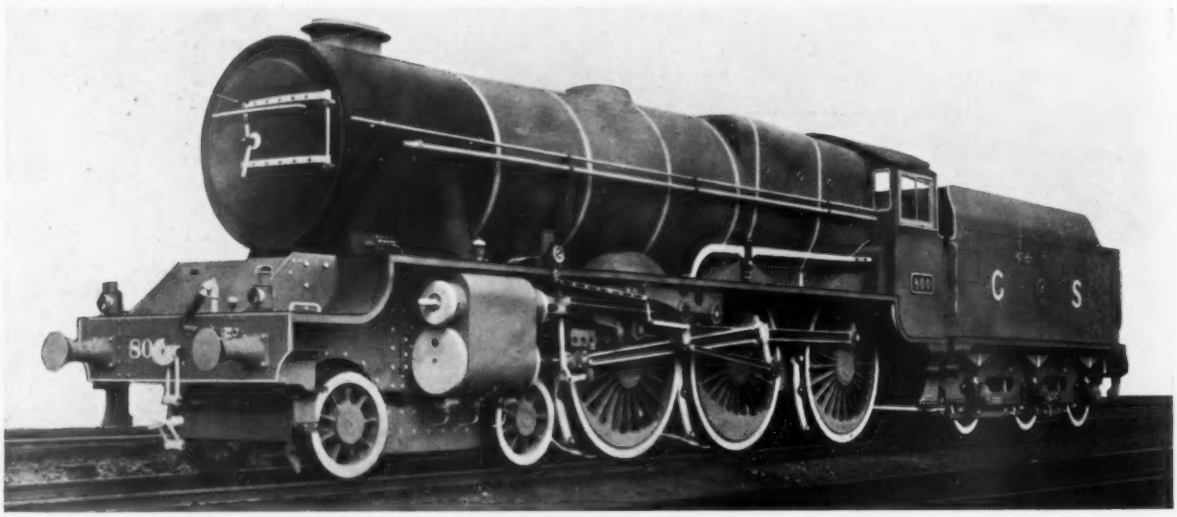
Container being hauled off railway truck on to channels of trailer conveyor extended to form a bridge between the two vehicles, and subsequently retractable; a new form of conveying containers introduced by the Netherlands Railways



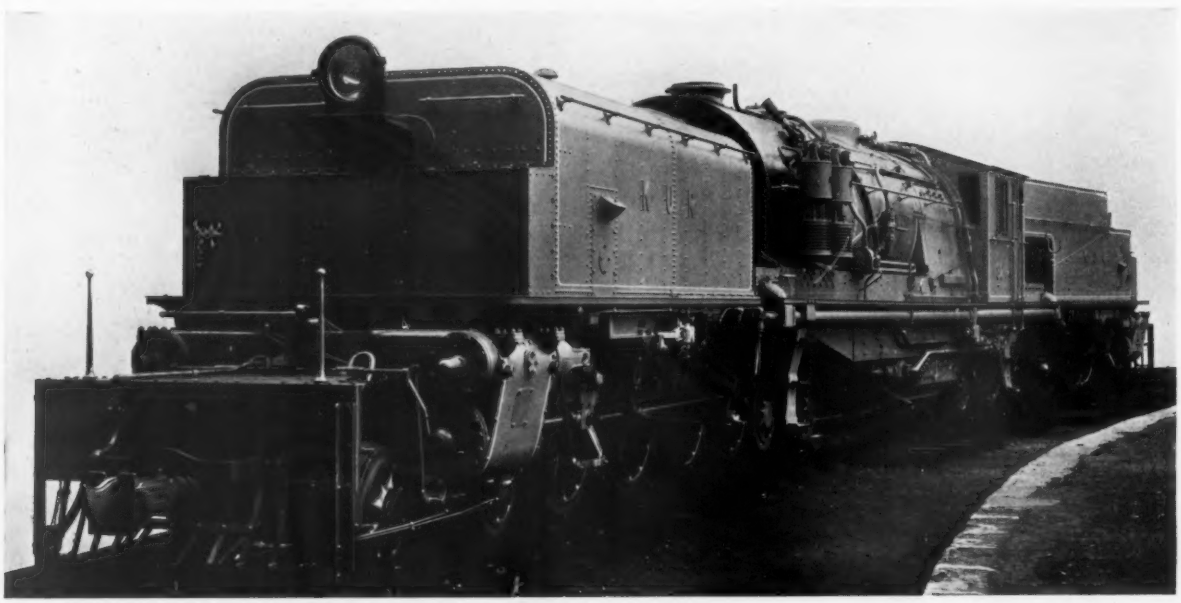
The Royal train in which the King and Queen made their tour across Canada approaching Jasper on its eastbound journey headed by Canadian National Railways 4-8-4 locomotive. In the background is Old Man Mountain



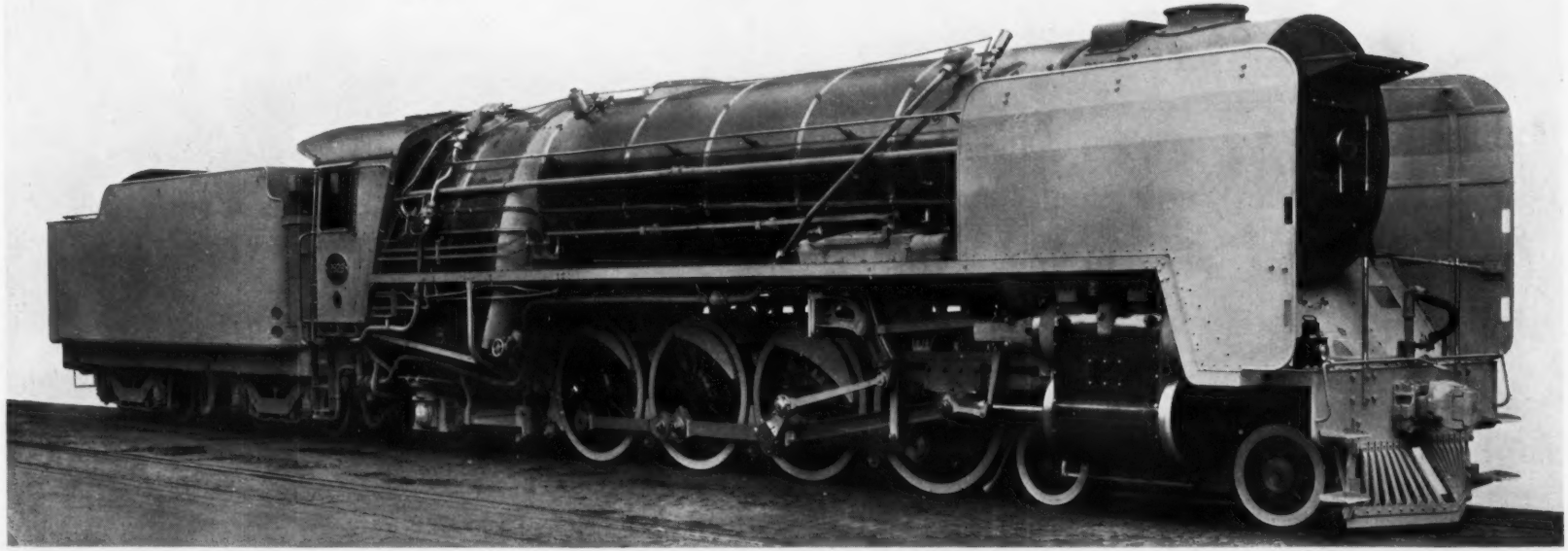
The last Nasmyth-Wilson locomotive, a metre-gauge 2-6-4 tank for the South Indian Railway



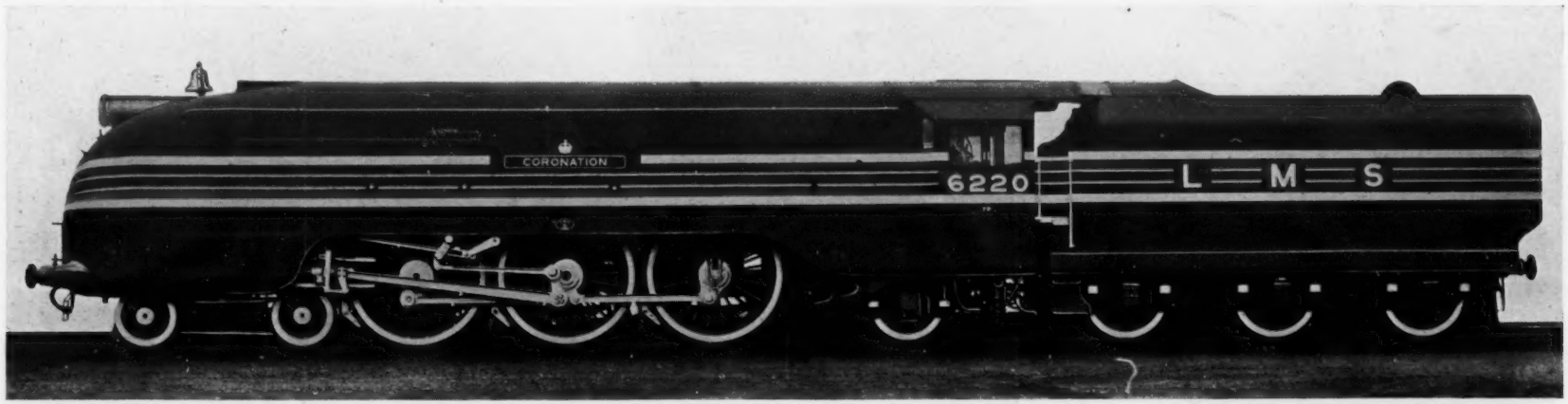
New 84-ton three-cylinder 4-6-0 locomotive, No. 800, "Maeve," Great Southern Railways, Eire



New 4-8-4 + 4-8-4 Beyer-Garratt for the Kenya & Uganda Railways, on a 275-ft. curve

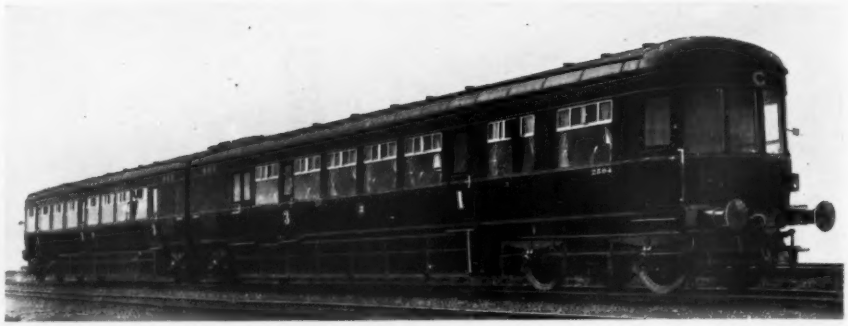


177-ton (with tender) two-cylinder 4-8-2 main-line engine, built by the North British Locomotive Co. Ltd. for the 3-ft. 6-in. gauge lines of the South African Railways. The maximum axle load is 18¼ tons

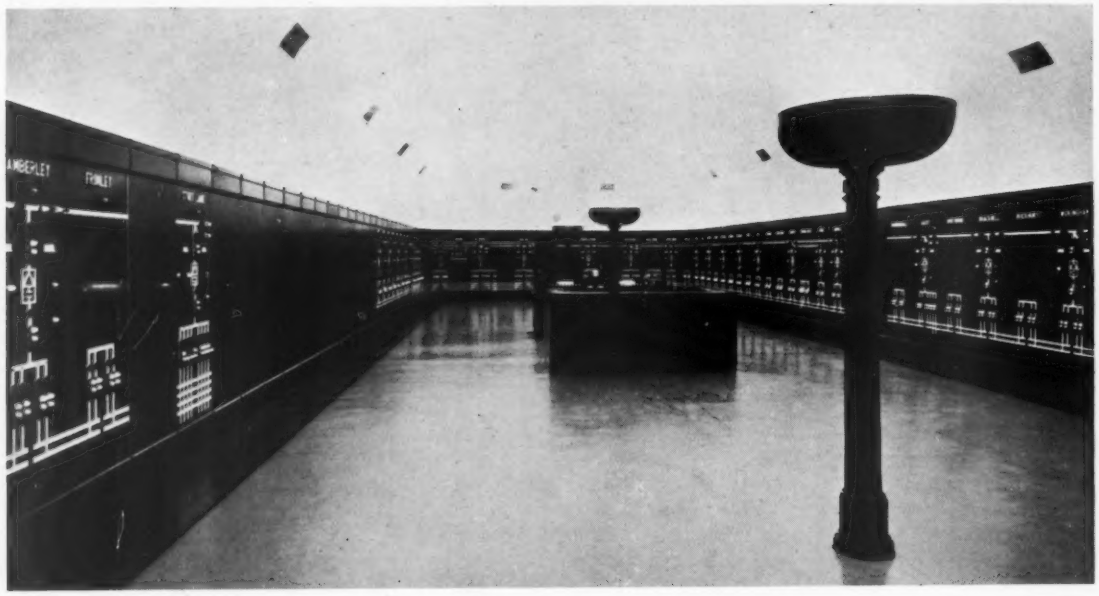


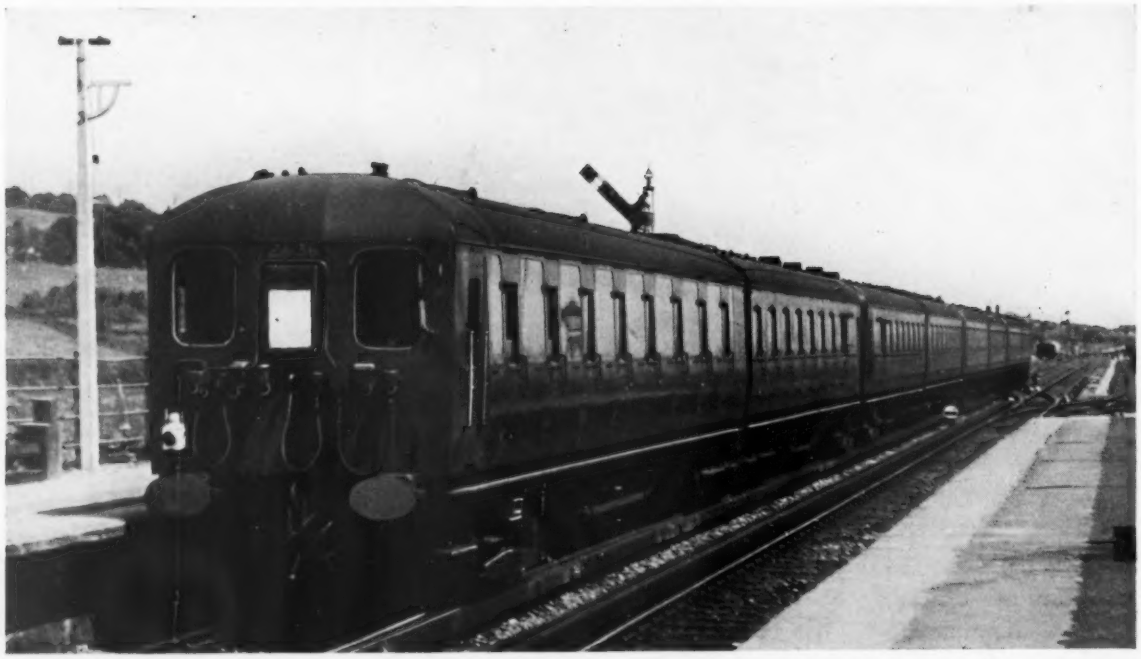
L.M.S.R. locomotive No. 6220, "Coronation," fitted with bell and headlight, ready for its trip, with complete train, to the U.S.A. In consequence of the war the locomotive and train are being stored at Baltimore

Right : One of the new 135 - seater twin - car articulated 400-h.p. Drumm battery trains for the Great Southern Railways Dublin-Bray suburban services

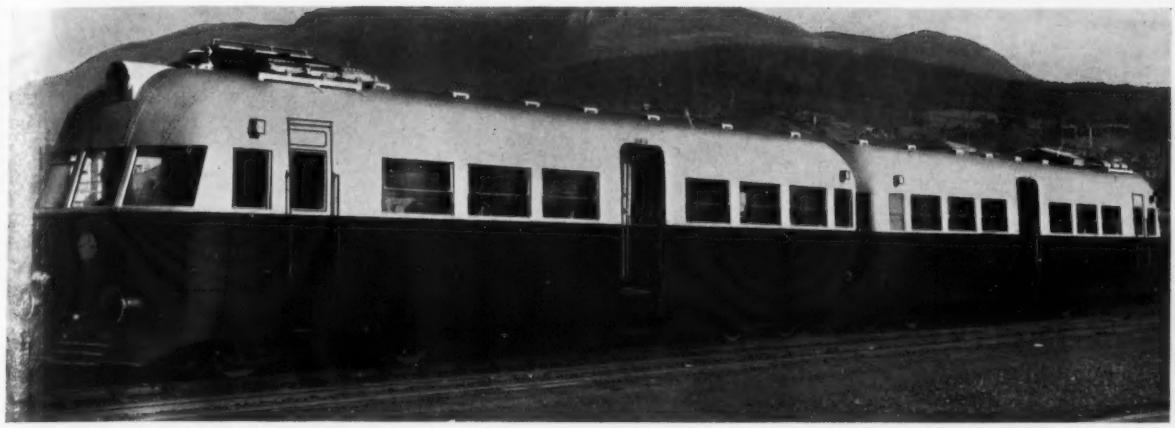


Below : Interior of Woking control room, Southern Railway, showing panels for the Reading extension



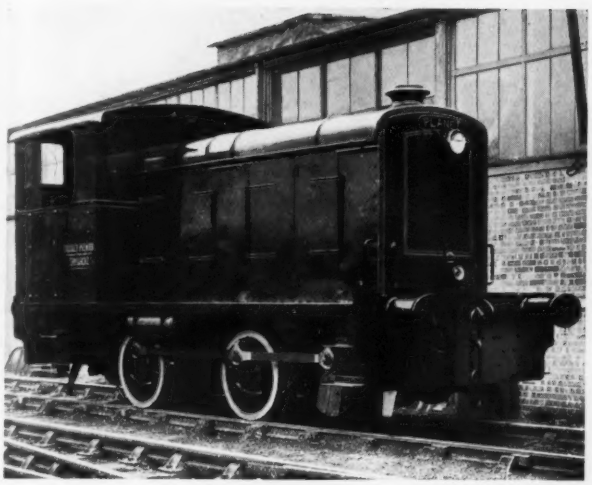


Train of 9-ft. compartment and corridor stock, made up of four two-car sets, Southern Railway Medway electrification

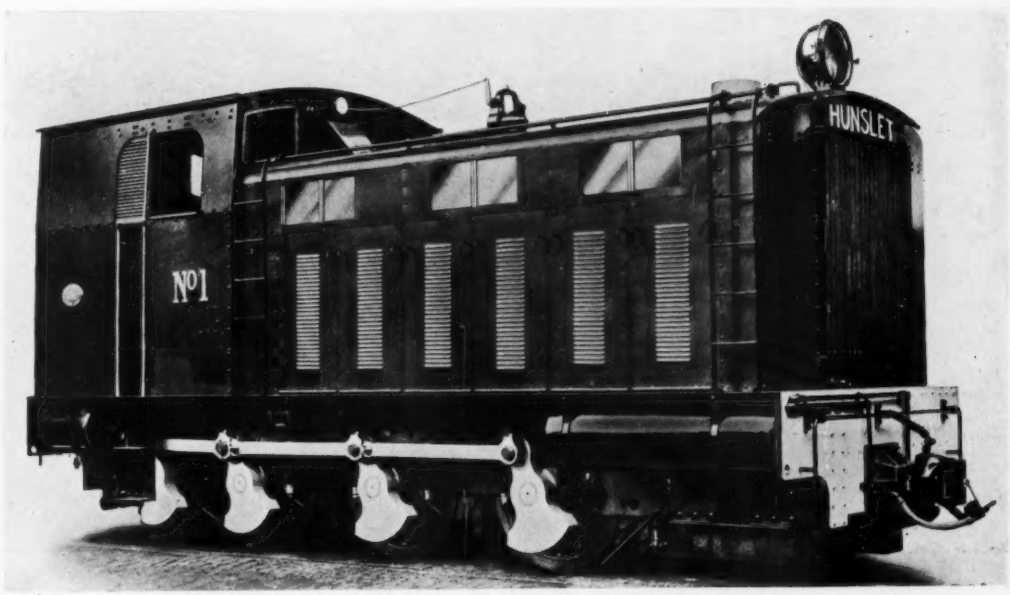


Above : Two of the new Tasmanian diesel railcars

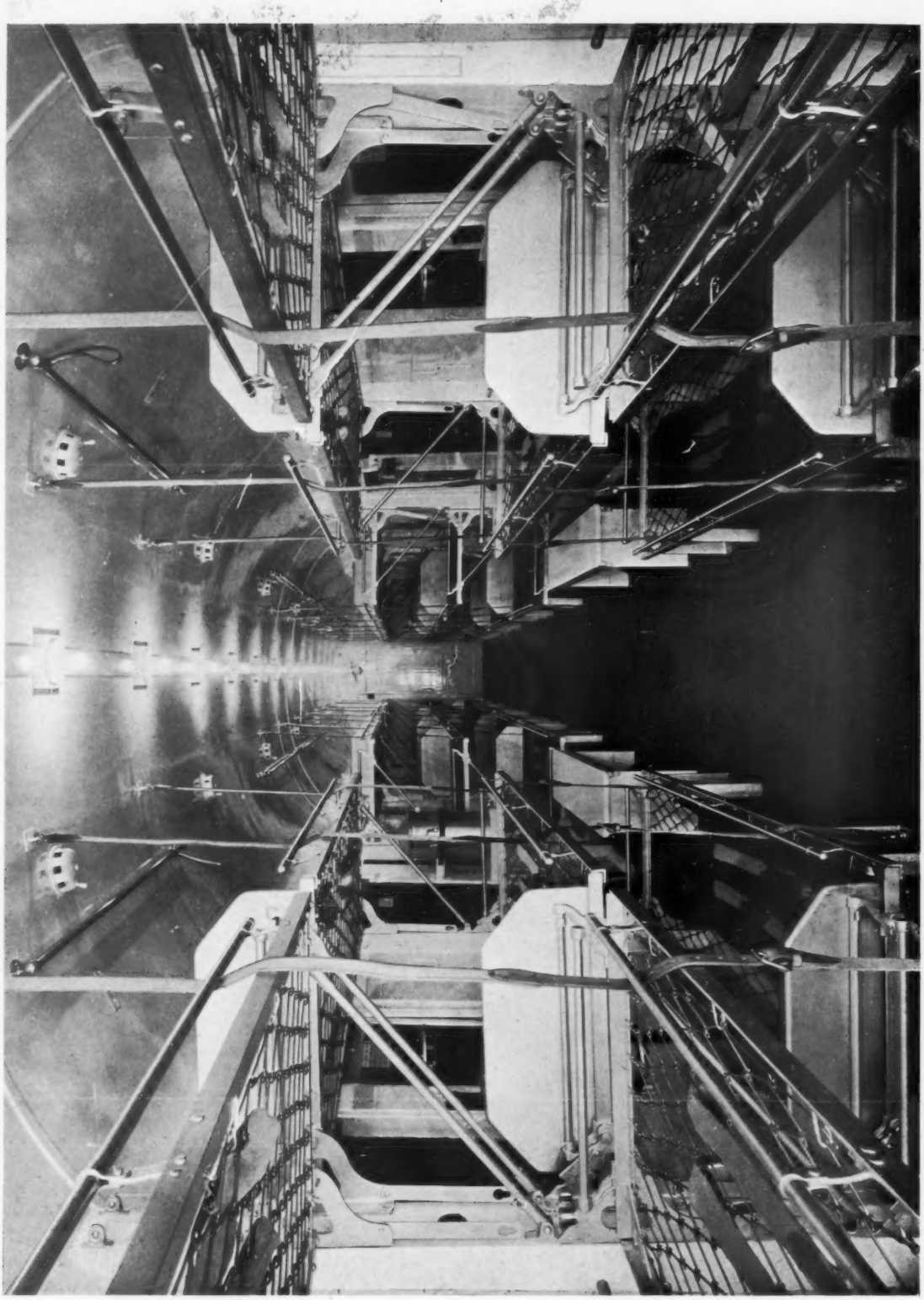
Below : One of the latest 20 L.M.S.R. diesel-electric shunters



Above : Hibberd diesel locomotive with Freeborn gearbox



Hunslet pressure-charged diesel locomotive for working at 15,000 ft. above the sea on the Guaqui-La Paz Railway

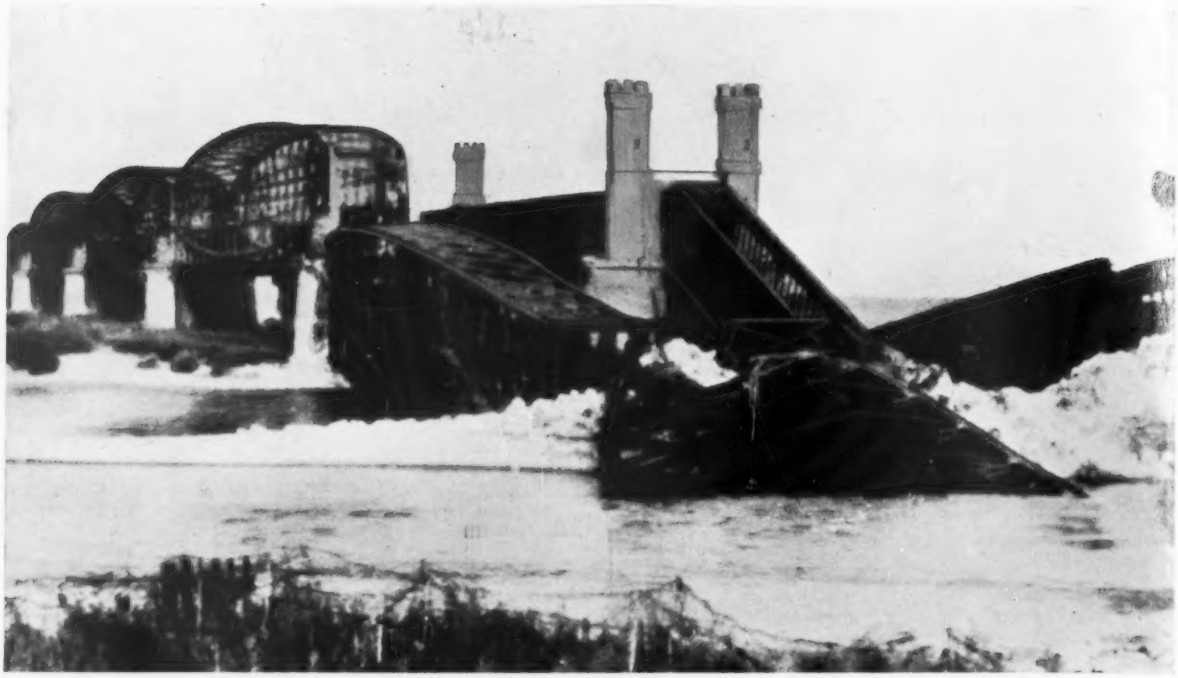


Interior of ward car, military ambulance train, fitted with 36 spring mattress bunks supported on the body sides in tiers of three, as equipped by the L.N.E.R. If necessary, the middle tier can be lowered, and the carriage used for 40 to 50 sitting patients

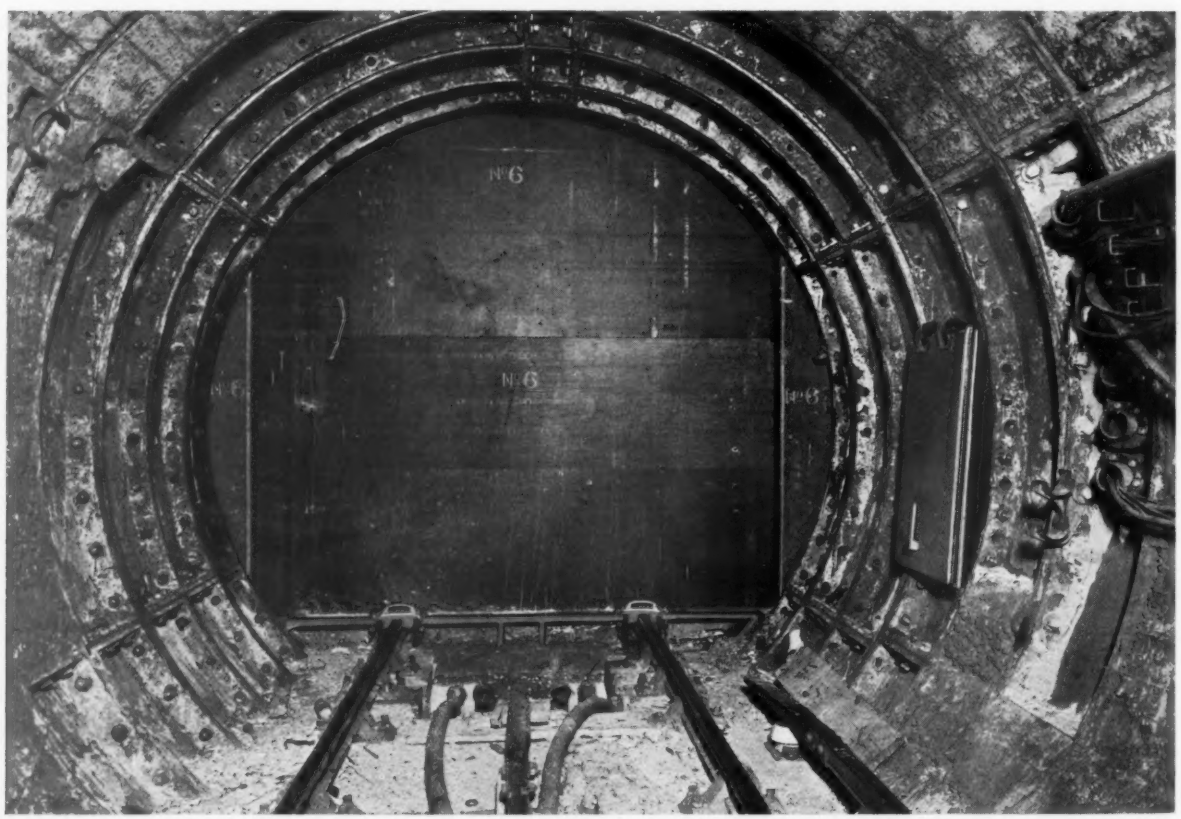
The lighting introduced by the Southern Railway in October and November. In open saloons (left) the white lights are not hooded, but in compartments (right) white lamps are only in hooded shoulder lights, one of which is shown inset

An aerial view of the industrial works and railway layout at Saarbrücken, which town is within a loop of the Siegfried line, and was a centre of military activity in the early days of the war

XUM



The destroyed railway bridge over the Vistula at Dirschau, on the Polish Corridor main line



L.P.T.B. protective works on tube sections below the River Thames. View of closed floodgate from railway tunnel showing blocks over running rails, cables leading into new ducts constructed outside railway tube, jumper cables through sill casting, and escape hatch

RAILWAY NEWS SECTION

PERSONAL

Mr. Walter S. Thompson, whose appointment as Chief Press Censor for the Dominion of Canada we announced in our issue of September 22, has relinquished this position to become Director of Public Information (established by Order in Council). According to Reuters, the general direction of the censorship will be carried out by a Censorship Co-ordinating Committee. Mr. Thompson is Director of Publicity for the Canadian National Railways and Trans-Canada Air Lines.

We regret to record the death of Mr. H. H. Gordon at the age of 66. Mr. Gordon graduated at London University in 1892 and later took the newly-established Mechanical Science Tripos at Cambridge. In 1895 he was appointed an assistant engineer to the East Indian Railway. Returning to England he became Assistant to the New Works Engineer, Great Western Railway. He worked in connection with the Institute of Travel Agents and a general business connected with travel agencies. In 1904 he was elected a member of the London County Council and from 1916-7 was Deputy Chairman. His L.C.C. work involved him in such questions as roads, electricity, and tramways. Mr. Gordon was a founder of the Institute of Transport, and acted as Chairman of preliminary meetings. During the last war, Mr. Gordon served as a commissioned officer.

Mr. Vincent Cartwright Vickers, whose death we announced in our issue of November 10, left property valued at £85,840 (net £76,755). Mr. Vickers was formerly a Director of Vickers Limited.

Mr. William Simpson Wreathall, whose death we recorded at page 409 of our issue of September 22, has left personal estate valued at £25,109 (net £24,443). Mr. Wreathall was a Member of Council of the British Electrical Federation; Chairman of Crosville Motor Services Limited, East Yorkshire Motor Services Limited, the National Electric Construction Co. Ltd., Ribble Motor Services Limited, W. C. Standerwick Limited, the Yorkshire Woollen District Transport Co. Ltd., and Blackpool Omnibus Stations Limited; and a Director of many other railway-associated provincial motorbus companies.

Mr. Raymond Carpmael, O.B.E. (Mil.), M.Inst.C.E., M.I.Mech.E., M.Inst.T., who, as announced in our issue of December 1, is retiring on December 31 from the post of Chief Engineer of the Great Western Railway, which he has occupied since January, 1929, was educated privately between 1883 and 1890, and then at Dulwich College. At Dulwich he spent two years on the science side and two on the engineering side, during which time attention was also paid to chemical research work. Between 1894 and 1899 he served a pupilage with Stothert & Pitt Limited, crane and harbour plant manufacturers, Bath, and supervised the erection of harbour cranes, &c., both in this country and in Germany, Mexico, and elsewhere. He then spent 18 months on the commercial side of the firm's business. In March, 1900, Mr. Carpmael entered the service of the Great Western Railway in the Bridge Department at Paddington, and in the next year was appointed by the late Sir James Inglis (then Chief Engineer) to be an assistant on the Fishguard harbour works under Mr. G. Lambert Gibson. In 1902 Mr. Carpmael was appointed Chief Assistant, in which position he was responsible for a great deal of the notable engineering work involved by the undertaking then in progress at Fishguard. During 1907 and 1908 Mr. Carpmael served as Resident Engineer under Mr. W. W. Grierson (then Chief Engineer) in charge of new works at Weymouth and Carmarthen. From 1909 he was Chief Assistant on the Shrewsbury Division, and in 1916 was transferred in that capacity to the Gloucester Division. During 1917 he was senior engineer in charge of No. 3 (G.W.R.) Civilian Railway Company, engaged in laying and maintaining railways, sidings, yards, and so forth, in France and Flanders. In 1919 he was appointed Divisional Engineer at Shrewsbury, and in 1922 was transferred to Neath in a similar capacity. Two years later he became Assistant to the Joint Chief Engineers at Barry, and, under the late Mr. W. Waddell, M.Inst.C.E., was responsible for civil engineering work at the company's docks. In January, 1926, he became Assistant to the Joint Chief Engineers at Paddington. Mr. Carpmael was appointed Chief Engineer in January, 1929, and is now retiring after 11 years' service in this capacity. Mr. Carpmael has made official inspections for the company of railway systems in the U.S.A., Germany, and France, and has attended meetings of the International Railway Congress in Madrid and Paris. In 1938 he visited India as a member of a committee appointed by the Government of India to investigate certain locomotive and track problems. Subsequently to his visit to America, Mr. Carpmael introduced petrol-driven trolleys on the G.W.R. for the conveyance of permanent-way men. This system is now in extensive use on the other main-line railways with material resultant economies. Mr. Carpmael is Colonel, Engineer & Railway Staff Corps, R.E. (T.A.), and is a Member of Council of the Institution of Civil Engineers, the Institute of Transport, the British Standards Institution, and the Permanent Way Institution (of which he was President for four years). He is also a member of many engineering societies, including the Institution of Mechanical Engineers, the Institution of Structural Engineers, the British Section of the Société des Ingenieurs Civils de France (also Vice-President), the Smeatonian Society of Civil Engineers, the Railway Engineers' Associa-

Photo] [Lafayette

Mr. Raymond Carpmael, M.Inst.C.E., M.I.Mech.E.

Chief Engineer, Great Western Railway, 1929—1939

tion, and the Building Research Board of Department of Scientific and Industrial Research. Mr. Carpmael has been Chairman of the G.W.R. Sectional Council No. 5 (Civil Engineering) since 1929, and for a period extending over five years has been Chairman of the Railway Clearing House Committee of Civil Engineers. He is a Trustee of Reading Municipal (General) Charities, a member of the executive committee of the Friends of the University of Reading, one of the Court of Governors of Bristol University, and a member of the Civil Engineering Committee of the Central Register, Ministry of Labour. Mr. Carpmael has received a number of awards from various engineering societies for papers read before them. In 1928 the Institute of Transport awarded him its Gold Medal (Engineering) for a paper entitled "Speed and Safety on the Railways"; in 1931 he received an Additional Thomas Hawksley Premium from the Institution of Mechanical Engineers, an award for a paper on "Steel Sleepers," for the extensive use of which on the G.W.R. he was responsible; and in 1932 he was awarded by the Institution of Civil Engineers a Telford Premium for a paper on "Cementation in the Severn Tunnel." Mr. Carpmael leaves the G.W.R. service with the cordial good wishes of the staff, not only at Paddington, but in many parts of the system where portions of his service were spent.

We regret to record the death of Herr Eivind Heiberg, who retired in 1938 from the general managership of the Norwegian State Railways. Herr Heiberg, who was born in 1870 in Oslo, studied at Trondhjem and in 1890 became a draughtsman in the Locomotive Department of the State Railways. Five years later he was appointed Divisional Locomotive Engineer. In 1899 he left the railway service to join the Skabo Waggon Works, Oslo, where he remained for 25 years until his appointment in 1924 as General Manager of the Norwegian State Railways. This position automatically gave Herr Heiberg the presidency of the management of the Norwegian Trunk Railway, and he also became a Member of the Committee dealing with the ferry connection between Norway and Denmark (Jutland). During his term of office, Herr Heiberg had the very strenuous task of piloting the Norwegian railways through the difficult depression years of 1931 and after. When he retired in 1938, most cordial tributes to his understanding and skill were paid by his colleagues.

The Institution of Locomotive Engineers

The following elections were made at the general meeting on December 14 :—

Members

Hugh Benedict Adams, Divisional Electrical Engineer, Workshop Division, North Western Railway, Moghalpura.

Albert James Baker, District Mechanical Engineer (Planning), South Indian Railway, Golden Rock.

Thomas William Brown, Chief of Central Materials Inspection Bureau, L.M.S.R., Derby.

John Patrick Cannon, Divisional Mechanical Engineer, North Western Railway, Delhi.

Major Houghton Aldgate Cotching, Chief Mechanical Engineer, Palestine Railways, Haifa.

Walter Anthony Fosberry, Transportation Supt. (Loco.), Assam-Bengal Railway, Chittagong.

Frederick Harold Hodgson, Boiler Engineer, New South Wales Govt. Railways, Redfern.

Harold Percival Homer, Asst. Works Manager, Bengal-Nagpur Railway, Khargpur.

George Rice Trevor Lewis, Loco. Supt. and Traffic Manager, Rio Tinto Co., Ltd., Rio Tinto, Spain.

Robert Lys William Meehan, Chief Mechanical Engineer, Eastern Bengal Railway, Calcutta.

Reginald Alfred Phillips, District Loco. and Carriage Supt., Bengal-Nagpur Railway, Khargpur.

Capt. William Powell, until recently Acting Works Manager (General), Bengal-Nagpur Railway, Khargpur; now recalled to Active Service.

Thomas Middleton Robinson, Personal Asst. to Chief Mechanical Engineer, North Western Railway, Lahore.

Robert Dalrymple Sandes, Supt. of Equipment, Bengal-Nagpur Railway, Khargpur.

Frank Livingstone Stafford, Chief Mechanical Engineer, F.C. Central del Paraguay, Sapucay.

George Bertram Steers, Asst. Loco. and Carriage Supt., Bombay, Baroda & Central India Railway.

Owen Rufus Tucker, Supt., Power, East Indian Railway, Calcutta.

Tzyh-Shin Wang, Asst. Mechanical Engineer, Nankow Works, Peiping-Suiyan Railway, China.

Associate Members

Stanley Edwin Acres, Asst. Carriage Works Manager, Madras & Southern Mahratta Railway, Perambur.

Iqbal Chand Bahree, Asst. Mechanical Engineer, North Western Railway, Lahore.

Geoffrey Ian Kinghorn Bennetts, Asst. to Traction Supt., F.F. C.C. Entre Rios y N.E.A., Concordia, Argentina.

Alfred George Brown, C.M.E. Dept., Kenya & Uganda Railways & Harbours, Nairobi.

James Mulholland Gregg Buchanan, Engineer and Draughtsman, L.M.S.R., Belfast.

James Newton Chalmers, Running Shed Foreman, Motive Power Dept., L.M.S.R., Inverness.

Robert Marr Dallas, Asst. Mechanical Engineer, North Western Railway.

George Ernest Langrish, Asst. Loco. Supt., Burma Railways, Insein.

Henry William Muter, Asst. Engineer (Designing), New South Wales Govt. Railways, Sydney.

Henly Nichols, Asst. Chief, Carriage & Wagon Works, F.C. Oeste, Liniers, Buenos Aires.

Henry Rideau, Dynamometer Car Officer, G.I.P. Railway, Parel, Bombay.

William Sidwell, Head Office Inspector (Mechanical), L.M.S.R., Hunt's Bank, Manchester.

Associate

Arthur Thomas Cooper, Asst. Chemist, F.C.P., Junin, Buenos Aires.

Transfers of Graduates to Associate Members

Alon Circuit Ap-Thomas, Chief Foreman, Loco. Shops, F.C. del Uruguay, Peñarol, Montevideo.

James Stanley Pigg, Acting Shed Foreman, Tweedmouth Running Shed, L.N.E.R.

Jack Lillico Smith, Supernumerary Running Shed Foreman, L.N.E.R., Doncaster.

Leonard Coulson Welborn, Running Shed Foreman, L.M.S.R., Motive Power Dept., Greenock.

Transfers of Associate Member to Member

Bertram Goddard, Supt., Mechanical Workshops, Bengal-Nagpur Railway, Khargpur.

Charles Robert Grey, Works Manager, North Western Railway, Mechanical Workshops, Sukkur, Sind.

John Wintle Maye, Works Manager, Bombay, Baroda & Central India Railway, Ajmer.

James Robert John Pett, Works Manager, Carriage Shops, North Western Railway, Moghalpura.

Louis Rigg, Loco. and Carriage Supt., Bikaner State Railway, Bikaner.

Norman Charles Watney, Div. Mechanical Engineer, North Western Railway, Karachi.

Indian Railway Staff Changes

Mr. W. G. Alcock has been appointed to office as Deputy General Manager, G.I.P.R., as from August 21.

Mr. W. Mills has been appointed to officiate as Superintendent of Mechanical Workshops, N.W.R., as from September 9.

Mr. E. L. Manley, Chief Engineer, E.B.R., has been permitted to retire from Government service as from October 6.

Mr. H. J. Mulleneux, Chief Electrical Engineer, G.I.P.R., returned from leave and resumed his duties on August 31.

Mr. R. G. Hugh has been confirmed as Deputy Chief Mechanical Engineer, E.I.R.

Mr. A. K. Homan, Divisional Superintendent, N.W.R., has been permitted to retire from Government service as from October 17.

The services of Mr. L. N. Flatt, Chief Mechanical Engineer, N.W.R., have been placed at the disposal of the Commerce Department of the Government of India, this notification cancelling the earlier one we recorded on November 17.

Mr. H. G. Jones on being recalled from leave, assumed the duties of Deputy Chief Mechanical Engineer (Locomotive Running), E.I.R., on September 30.

Mr. G. H. A. Wood has been appointed to officiate as Director, Railway Clearing Accounts Office, as from October 24.

Mr. C. Bhaskaraiya has been appointed to officiate as Deputy Chief Accounts Officer, E.I.R., from Oct. 15.

Mr. Ernest Archer, L.N.E.R. Agent at Billingsgate, has retired after 51 years of railway service. He has the proud distinction of never having been late on duty or absent for a single day through sickness.

Sir George E. Clark, a Director of Sentinel Waggon Works (1936) Limited, has resigned.

Mr. Edgar Macassey has just resigned his position as Chairman of the Traffic Commissioners for the West Midland Area. Mr. Macassey was educated at Dublin University and then joined the staff of Speyer Brothers, the famous firm of merchant bankers, which was closely associated financially with the Underground Electric Railways Co., London, Ltd. When Mr. Macassey left the firm to enter the law, he continued to maintain the interest in transport which his financial and banking experience had begun. His practice was mainly before Private Bill committees, and during the past 20 years he has been concerned in most of the new legislation affecting road transport. Mr. Macassey was appointed by the Minister of Transport to succeed Mr. Trevor Morgan as Chairman of the Traffic Commissioners for the West Midland Area, towards the end of last year, as recorded at page 1005 of The Railway Gazette for December 9, 1938.

SOUTHERN RAILWAY APPOINTMENT

The directors of the Southern Railway Company have appointed Mr. R. M. T. Richards, Assistant Traffic Manager, to be Traffic Manager, as from January 1, 1940, during the period in which Mr. E. J. Missenden (in the absence of Mr. Gilbert Szlumper, now Director General of Transportation and Movements, War Office), holds the position of General Manager of the Southern Railway.

Mr. Arthur Roose, Chief Clerk of the Rate and Tariff Bureau, Freight Traffic Department of the Canadian National Railways, Montreal, is retiring after 40 years' service. Mr. Roose was born at Bakewell, Derbyshire, in 1879, and went to Canada in 1899.

IRISH RAILWAY CLEARING HOUSE

Mr. P. J. Floyd, Traffic Manager, Great Southern Railways, has been unanimously elected Chairman of the Traffic Officers' Committee for the year 1940.

The Executive Committee of Communications and Works has decided, on the advice of the Public Service Commission, to recommend the appointment of Mr. W. G. Hills as General Manager of the Ceylon Government Railway, at a salary of £1,750 a year.

The Secretary for Mines has appointed Lord Cadman to be Honorary Adviser on oil, and Sir Harold Hartley to be Honorary Adviser on the development of home-produced fuels. Lord Cadman is a Director of the Great Western Railway, and Sir Harold Hartley is a Vice-President of the London Midland & Scottish Railway.

M. Marck, Belgian Minister of Transport, has resigned.

We regret to record the death at Epsom on December 20 of Mr. Harry John Fereday, until March, 1937, a Partner in the firm of Messrs. Rendel, Palmer & Tritton, consulting civil engineers, of Westminster.

We regret to announce the death on December 16 at Lahore, Punjab, India, of Dr. James Cairns, C.I.E., O.B.E., E.D. Dr. Cairns was at the time of his death Chief Medical and Health Officer, of the North Western Railway of India.

We regret to record the death on December 21 in his 76th year of Mr. Arthur Beresford Cane, C.B.E. Mr. Cane, who was called to the Bar at the Inner Temple in 1890, was appointed Secretary to the Railway Companies' Association in March, 1909, and held that position until his retirement at the end of 1929. In 1925 Mr. Cane acted as Joint Secretary (with Mr. H. Marriott) of the Arrangements Committee of the Tenth International Railway Congress, which was held in London to coincide with the railway centenary celebrations at Darlington.

STAFF AND LABOUR MATTERS

Railway Wages

A meeting between representatives of the railway companies and representatives of the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Railway Clerks' Association, was held in London, on Thursday, December 21, when applications for increases in salaries and wages were presented by the trade unions. The National Union of Railwaymen, as announced in our issue of December 15, had submitted an application for an all-round increase of 10s. a week owing to the rise in the cost of living. The union also desires alterations in the cost of living sliding scale arrangements, which automatically regulate wages in accordance with the cost-of-living index figures published by the Ministry of Labour and National Service. The Associated Society of Locomotive Engineers and Firemen is also asking for an increase of 10s. a week, while the Railway Clerks' Association is making application for an increase of £20 per annum in salaries, with an alteration in the cost of living sliding scale arrangements. The meeting held on December 21 was merely to explore the claims, and the official statement issued at the close of the meeting said that the trade unions explained the reasons which prompted their applications, and the representatives of the railway companies undertook to examine the position and to give a considered reply at a further meeting.

Decision No. 6 of the Railway Staff National Tribunal will be implemented by the railway companies in the new year. The following announcement was issued immediately before Christmas :—

" The Railway Executive Committee announces that the decision (No. 6) of the Railway Staff National Tribunal dated October 18, 1939, which has been accepted by all the parties, will be brought into operation so that the necessary payments to the men will be made in connection with the first full pay period in the new year. This will be applied retrospectively in accordance with the decision of the tribunal as from the beginning of the first full pay period following October 28, 1939. The consequential advances which are necessary as a result of the new minimum rates are being dealt with between the railway companies and the trade unions and effect will be given to these as soon as agreement is reached."

Cost-of-Living and Railway Wages

The cost-of-living index figure published by the Ministry of Labour and National Service rose from 69 at November 1 to 73 at the beginning of December. This is 18 points higher than it was when the war began and is the highest figure since January, 1927. The wages of adult conciliation and certain other railway grades are governed by a cost-of-living sliding scale and, under these arrangements, increases of 1s., 2s., or 3s. a week will become due at January 1, 1940. The scheme provides that every five points rise in the governing cost of living figure shall carry with it an increase of 1s. a week ; conversely, if the cost of living is falling, a reduction of 1s. for every five points fall in the governing figure.

Every grade has a datum cost-of-living figure at or below which base rates are payable and the current rates are based on a " governing " cost-of-living figure which is a multiple of five points. The present governing figure is 55, and, with the index figure rising to 73, the governing figure from January 1 will be 70. Thus the staff with a datum figure of 55 or below will receive an increase of 3s. and those with datum figures of 60 and 65 will receive increases of 2s. and 1s. respectively. The Railway Staff National Tribunal in its Decision No. 6 awarded new minimum rates of pay at the governing figure of 55, therefore the whole of the staff on the new minimum rates will receive a further increase of 3s. on January 1 under the sliding scale arrangements.

Miners' Wages

A claim for a further increase in the wages of miners is being considered by the Joint Consultative Committee, representing the owners and the miners. The miners are pressing the owners for a formula which will automatically control the rise of wages in accordance with the movement of the cost-of-living index figure.

The British mineowners have offered to increase miners' war wages from January 1 by 4d. a shift for men and 2d. a shift for lads. This would bring the total increase since the war began to one shilling for men and sixpence for lads. The offer was made at a meeting in London of the joint consultative committee for the industry on December 20. At the close of the meeting Mr. W. Lawther, President of the Federation, said the executive was extremely disappointed with the offer and it had decided to convene a special national delegate conference for Friday, December 29. " In the meantime," added Mr. Lawther, " we are seeking a meeting with the Government to place before it our claims for an advance in keeping with the cost of living. The figure offered for January by the owners is, in our opinion, neither adequate nor representative of the advance that has taken place in the cost of living since we had our last advance."

Electricity Supply Workers' Wages

The National Joint Industrial Council for the Electricity Supply Industry has agreed that workers employed by electricity supply undertakings shall have their wages increased forthwith by ¾d. an hour. About 100,000 men employed throughout the country, as well as in Northern Ireland, are affected by the decision.

XUM

TRANSPORT SERVICES AND THE WAR—18*

Train lighting twenty-five years ago and now—Christmas holiday traffic—Transport of troops and munitions—Southern Railway station A.R.P.—Casualty evacuation trains—War priority regulations in Canada—Further French train service improvements

The approaching end of a calendar year provides a convenient time to "stocktaking," and the main part of this issue of THE RAILWAY GAZETTE is devoted to a retrospect—pictorial and textual—of the past twelve months. The whole period has been overshadowed, first by the risk and then by the actuality of war, but members of the travelling public remained almost completely unaffected by defence preparations until the few days of crisis which preceded the outbreak of war. It is difficult to avoid making comparison between the early days of the present conflict and those of twenty-five years ago, especially as in many respects the intervening years now appear to have been a lengthy armistice, and our war transport activities are in so many ways a development of all that proved effective before.

One notable difference between 1914 and 1939 is that this time hostilities began four weeks later, towards the end of the holiday season and not at its height. For the vast majority of holidaymakers, therefore, the past ten days have been their first wartime holiday period, and they have enjoyed the benefit of railway facilities which, although curtailed, are vastly superior to those available a few weeks ago. Sleeping and restaurant car services were running—and were augmented for the Christmas holidays, lighted trains are now widespread, and the worst of the gloom had already been lifted from many station premises before the holiday traffic began. In the past few days the British railways ran 1,500 extra trains to cope with the holiday traffic; 250 of these carried parcels and bags of Christmas mail, and numbers of trains were provided specially for those members of the Forces able to obtain leave. Strenuous efforts were made to equip with reading lighting as many carriages as possible, and more than 400 fully-lighted restaurant and buffet cars were in service, as well as nearly 300 sleeping cars. Nevertheless, the traffic demands were such that the duplicate portions of some of the main long-distance trains were without light and without restaurant or buffet facilities. As a correspondent pointed out in our columns last week, however, real wartime services had not been imposed by Christmas, 1914, so that then the general trend was towards deterioration, whereas now the tendency is all-round improvement.

Train Lighting in 1914–18

Especially at Christmastime, which in peace is a period of illumination, it is of interest to recall something of the train-lighting restrictions that applied during the days of 1914-18 when the possibilities of aerial bombardment were first demonstrated. In the early days of that war, lighted trains were found by our own pilots to make railways so conspicuous at night that, towards the end of October, 1914, the Admiralty (which was then responsible for the anti-aircraft organisation) suggested to the Railway Executive Committee that notices should be placed in every railway compartment asking passengers to keep blinds drawn at night. This was done, but proved insufficient for various reasons. Passengers failed to co-operate, and many third class carriages had no blinds. Some carriage lights were therefore shaded (with hoods carrying advertisements) and door windows unprovided with blinds were either painted or (as in the Isle of Wight) covered with brown paper. During the next winter, in December, 1915, the Home Secretary issued an Order under the Defence of the Realm Regulations requiring the intensity of station and other railway lighting

London Brighton & South Coast Railway.

PASSENGERS TO LOWER BLINDS

Extract from an

Order of the Secretary of State.

During the period between 6.0 p.m. and Sunrise, passengers in Railway Carriages must keep the blinds lowered so as to cover the windows. The blinds may be lifted in case of necessity when the train is at a standstill at a station, but, if lifted, they must be lowered again before the train starts.

LONDON BRIGHTON AND SOUTH COAST RAILWAY.

IMPORTANT

REDUCED LIGHTING.

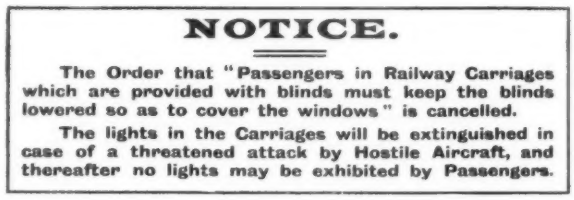
The attention of Passengers is called to the necessity of satisfying themselves before alighting that the train has come to a stand at the station platform. This is important during the hours of darkness when the blinds are drawn.

CLOSING COMPARTMENT DOORS.

Owing to the Enlistment of Railwaymen and consequent shortage of Staff, the Railway Company earnestly request the co-operation of Passengers in closing the carriage doors after entering or leaving Trains at intermediate Stations.

Reduced lighting instruction posted in L.B.S.C.R. compartments during 1915–1917

to be reduced to the minimum that would "suffice for the safe and expeditious conduct of business," and making the lowering of compartment blinds a matter of compulsion, with the provision of heavy penalties for infringement. Although this resulted in some improvement in the behaviour of passengers, the strict enforcement of the Order entailed considerable trouble. Eventually a new method of procedure was adopted, and in March, 1917, the Home Secretary withdrew the Blinds Order. Thereafter, carriage lights were


NOTICE.

The Order that "Passengers in Railway Carriages which are provided with blinds must keep the blinds lowered so as to cover the windows" is cancelled.

The lights in the Carriages will be extinguished in case of a threatened attack by Hostile Aircraft, and thereafter no lights may be exhibited by Passengers.

Compartment notice issued when the "Blinds Order" was withdrawn in March, 1917

extinguished in case of a threatened air raid. In February, 1918, the Order for lowering blinds was renewed in the case of trains on sections of line visible from the sea and river estuaries.

The Transport of Troops and Munitions

During the first three months of the war more than 5,500 special trains were run by the British railways for the conveyance of troops and munitions. With more than a million men in training, and further drafts on the way, the number of men and women in uniform travelling by train is constantly increasing. When travelling to training camps, medical boards, depots, and on leave, members of H.M. Forces are provided with railway warrants which are exchanged at railway stations for tickets. Where a long journey has to be made they are also issued with a warrant which entitles them to meals at special prices in railway

* Previous articles in this series have been "Transport Services and the Crisis," Sept. 1, p. 334; and "Transport Services and the War," Sept. 8, p. 358; 15, p. 382; 22, p. 410; 29, p. 442; Oct. 6, p. 467; 13, p. 495; 20, p. 525; 27, p. 557; Nov. 3, p. 589; 10, p. 617; 17, p. 649; 24, p. 681; Dec. 1, p. 714; 8, p. 746; 15, p. 781; and 22, p. 817

refreshment rooms. The railways are connected by direct telephone lines to the War Office, the Admiralty, and the Air Ministry. Every day they arrange at the request of the Service Departments to run special trains for transporting arms, guns, ammunition, wagons, baggage, stores, and horses. Private sidings linked with ordnance depots and factories are served by trains which run to and from these centres direct.

A constant supply of gas cylinders is required to keep barrage balloons in the air and this has created an entirely new type of railway traffic. Special wagons known as low-fits, the sides and ends of which drop, are employed on this work. Road vehicles loaded with gas cylinders are run direct on to wagons, thus obviating loading and unloading of the cylinders into the railway trucks. In addition, more than 50,000 specially built railway wagons are in service for consignments of exceptional weight and dimensions, such as large guns and armour plates. Large demands are made upon these heavy-weight wagons and a close watch upon their movements is kept day by day to make the best possible use of every vehicle for every journey. Numbers of wagons have been converted to carry explosives, and much ingenuity has been shown in the methods adopted in designing and adapting fittings such as special racks for shells and bombs which travel by railway *en route* to their destinations. Large tonnages of fuel supplies—oil, coal, and petrol—for the Fleet, the Army, and the Air Force are also moved by rail, in addition to trainloads of supplies for blast furnaces, steelworks, and other large undertakings which are working night and day producing armaments.

"M" Sign on Bakerloo Line

Passengers on the Bakerloo Line should experience no more difficulty in knowing whether, after having left Baker Street, a train will branch off to the Queens Park and Watford line or to the Metropolitan Line and Stanmore section. From the morning of December 12 all trains for Wembley Park and Stanmore have been marked on the front with a large "M." This is only a temporary measure until all stations from Elephant & Castle to Baker Street have been equipped with automatic destination indicators, the delivery of which has been delayed by the war. On this page we reproduce the two London Transport posters which have been issued to notify passengers of the arrangement and to warn them of the necessity for care.

BAKERLOO LINE

Watch your train

M TRAINS FOR THE STANMORE SECTION ONLY

LONDON TRANSPORT

A TRAFFIC NOTICE

PASSENGERS FOR BAKERLOO LINE

The Bakerloo Line now serves Wembley Park and Stanmore as well as Queens Park and Watford; passengers going North to Stations beyond Baker Street are advised to ascertain the destination of a train before they board it

Alternate trains to the Stanmore Line run to Wembley Park only

LONDON TRANSPORT

Two London Transport posters issued in connection with the projection of Bakerloo Line trains to Stanmore

Southern Railway Station A.R.P.

Arrangements were made by the Southern Railway for an A.R.P. scheme to be prepared for every station on the system; this includes the nomination of a Chief Warden and Deputy Wardens, the allocation, or if necessary the provision, of special shelter accommodation for the staff, and (so far as the larger stations are concerned) the institution of A.R.P. squads for fire fighting, first-aid, decontamination, and demolition services. These station schemes are now practically complete, the shelter accommodation at stations coming within the "scheduled areas" having been brought up to the standard required by the code of the Civil Defence Act, 1939. The training of A.R.P. personnel, for which some 3,000 members of the company's staff have volunteered, has, in itself, been a big task, but this work is nearing completion. The wholehearted manner in which the personnel have thrown themselves into the training of A.R.P. work, is exemplified by the fact that no fewer than 24,000 members of the staff have attended lectures and demonstrations which have been arranged by the company. Decontamination and cleansing centres are being provided at principal stations and depots which are situated at such a distance from the municipal and other local cleansing facilities as to make it impracticable for the company's staff to take advantage of them.

Casualty Evacuation Trains

It would seem from a recent question in the House of Commons that there is still some misunderstanding about the position of casualty evacuation trains, for on December 7, Sir A. Knox asked the Minister of Health whether he was aware that 32 trains, each with eight officials of the St. John Ambulance Association, were at present standing idle, and inquired what was the weekly cost of these officials, and why the trains and personnel could not be assembled quickly in case of an emergency. In reply Mr. Elliot said that the casualty evacuation trains which, owing to the course the war had taken, had happily not been used to a great extent, had hitherto numbered 28 apart from two in Scotland. He announced that the number was now being reduced to 18 and said that the weekly cost of the orderlies averaged about £26 a train. Mr. Elliot pointed out that the mobility of the trains and the need for keeping them and their equipment in constant readiness for immediate service, if required, made it necessary to keep trains and staff continually in commission. Details of these casualty evacuation trains have been published in THE RAILWAY GAZETTE (October 20 and November 24 issues) and it has already been pointed out that although 34 trains were prepared and equipped at the request of the Ministry of Health, four were loaned to the War Office. Although two were afterwards returned, the vehicles composing them have since been distributed for ordinary traffic but are available for re-conversion and assembly into trains at 24 hours' notice. Now that the total is being reduced by ten, similar remarks will apply to the vehicles composing these trains.

Military Ambulance Trains

By the second week in October all the military ambulance trains prepared to War Office requirements for service both at home and overseas had been completed. These trains, which have formed the subject of two illustrated articles in THE RAILWAY GAZETTE (November 10 and December 8 issues),

total 136 vehicles, and consists of eight nine-vehicle trains for home service, and four 16-vehicle trains for overseas service.

Locomotives for Overseas War Service

On December 8 we recorded that, of the G.W.R. "2301" class 0-6-0 locomotives of the late Mr. W. Dean's design which have been allocated for war service overseas, certain have been released direct from Swindon works and others have undergone repairs at the Eastleigh works of the Southern Railway. The details are as follow:—

Swindon			Eastleigh
No. *2533	No. 2512	No. 2393	No. 2402
,, 2439	,, 2436	,, 2456	,, *2403
,, 2486	,, 2565	,, 2547	,, 2410
,, *2518	,, 2561	,, 2567	,, *2461
,, 2539	,, *2480	,, 2427	
,, 2419	,, 2524	,, 2490	

Those engines marked with an asterisk also did service abroad during the war of 1914-1919.

War Priority Regulations in Canada

Regulations providing for priority of movement by land and water of troops, naval forces, and munitions of war, have been drafted by the Canadian Minister of Transport, Mr. C. D. Howe, approved by the Cabinet, and published in the *Canada Gazette*. Mr. T. C. Lockwood, the Montreal shipping executive, has been appointed Transport Controller under the scheme, and his duties will be to deal with applications for priority of transport. These applications will be made on behalf of the Canadian Government, the British Government, the Government of France, and any other government or agency, including those of private business interests. All transport companies, agencies, organisations, and associations, and all owners and charterers of British ships registered in Canada in which cargo space may be required, must act in accordance with the orders issued by the Transport Controller, on behalf of the Minister of Transport, and in respect to railway transport the Transport Controller will issue all orders for transport to the Railway Association of Canada, which acts on behalf of the railway companies concerned. The Transport Controller is also instructed to co-operate with the Canadian representative of the British Ministry of Shipping in all matters relating to the transport of troops, naval forces, materials, and supplies required by the British Government in the prosecution of the war.

German-Occupied Poland

On October 12 through rail communication was opened between East Prussia and Upper Silesia *via* Warsaw, a train leaving Königsberg for Oppeln on that day. Much of the route traversed, *via* Ostrolenka, Siedlce, Warsaw, Tschenstochau, and Lublinitz, had been very badly damaged by both the Poles and Germans during the fighting, and considerable bodies of troops were required to restore the track and equipment. The two important bridges over the Narew and Bug were destroyed by the Russians in the 1914 war and temporarily replaced by German military engineers. It is stated that the Poles had not replaced them by regular bridges during the 20 years since the peace, so that it proved very easy to damage the temporary wooden structures this time. Much damage was done to points, crossings, telephones, and water supply equipment by the Poles; long lengths of track were also damaged in places. It is stated that in Warsaw several railway workshops and other offices are now working under German supervision and that a representative of the Reichsbahn is stationed in the Polish Ministry of Transport to manage railway matters. Beyond Warsaw on the route to Oppeln the working has been brought almost back to normal.

Germany has issued a Decree confiscating all Polish State property in the territory occupied. State-owned properties included the State coal mines near Krakow, the State Railways, and the Polish port of Gdynia. The building of Gdynia is stated to have cost the Polish State over £100,000,000. Polish State Railways owned about 5,400 locomotives, 11,900 carriages, and some 160,000 goods wagons. Most are believed to have fallen into German hands. It is reported that the machinery at the industrial works of Cegielski at Rzeszow, east of Krakow, the greatest locomotive factory in Poland, is being dismantled to be transferred to Germany.

Germany is planning to convert the cabins of her Zeppelins into tanks to bring petrol from Russia, the Berlin correspondent of the Amsterdam *Telegraaf* understands.

Further French Train Service Improvements

Various improvements of French train services, additional to those announced in our December 8 issue, figure in a new issue of the *Indicateur Chaix*, operative from December 1. Of these the most interesting are a series of express railcar services in the Western Front region, calling at principal stations; they run three times daily in each direction between Mulhouse and Strasbourg, calling at Colmar and Sélestat, and similarly between Strasbourg, Sarrebourg, Metz, and Thionville. As to running times, the 67½ miles between Mulhouse and Strasbourg are covered in from 83 min. (48 8 m.p.h.) upwards, the 43½ miles between Strasbourg and Sarrebourg in an hour, and the 54¾ miles between Sarrebourg and Thionville in from 72 min. upwards. The route is, of course, the Alsace—Lorraine main line of the Eastern Region, served since the outbreak of war only by *omnibus* trains calling at all stations; and in view of the proximity of the line to the fighting front, the institution of such rapid communications along its length is remarkable. Not only so, but travel between Paris and all parts of the front has thereby been expedited; and these railcars make direct connection at Saverne with the express services between Saverne and Paris, so that Strasbourg now has three daily services to and from Paris in 7 hr. 34 min. to 7 hr. 56 min., as well as a night train in each direction. Similar railcar services, three times daily, run between Mézières—Charleville and Longwy, in connection at Mézières with the Paris expresses *via* Rheims; these now reduce the Paris—Longwy overall time to between 5 hr. 31 min. and 5 hr. 52 min., and improve the communication between France and Luxembourg.

Through workings between France and neighbouring countries have been materially improved. The Simplon-Orient Express includes sleeping cars from Paris to Rome (*via* Milan), Bucharest, Athens, and Istanbul. Through sleeping cars are also running from Paris to Rome *via* Modane and Turin, and Paris to Berne, *via* Delle. From the Riviera sleeping cars are working from Nice to Milan, Rome, and Budapest. Through coaches are operating twice daily in each direction between Paris and both Basle and Berne *via* Delle; between Paris and Berne *via* Dijon, Pontarlier, and Neuchatel; also between Paris and Milan *via* both Delle and Pontarlier to Berne, and from there *via* the Loetschberg line. To and from the Spanish frontier sleeping car services are provided twice nightly in each direction between Paris and Hendaye, one of these trains travelling *via* Biarritz, and also between Paris and Cerbère (for Barcelona) *via* Toulouse. In view of the weight of the trains, internal sleeping car services in France have been cut down to a minimum, and in addition to those already mentioned the only cars operating are between Paris and Mentone, Paris, and Tarbes, and Paris and Lyons *via* St. Etienne; all the sleeping car services are both first and second class. But there has been, by way of compensation, a wide extension of first class *couchette* facilities; these are now provided from Paris, to Nancy and Saverne, Belfort, and Mulhouse, Quimper, La Rochelle and Saintes, Le Croisic, Tarbes, Toulouse, Rodez, Aurillac, Sète, Besançar, Geneva, Grenoble, Nîmes, Arvant, St. Etienne and Lyons, and Mentone, as well as across country between Lyons and Bordeaux, Lyons and Mulhouse, and Lyons and Le Croisic. Over numerous main lines the daily express services have now been increased from three to four or five in each direction. A note printed inside the cover of the *Indicateur Chaix* calls attention to the fact that trains may be delayed or suspended by reason of military exigencies, and strongly urges passengers to reserve their seats in advance, as practically all the fast services have limited seating accommodation. This is in striking contrast with conditions in Great Britain, where seat reservation has been suspended.

QUESTIONS IN PARLIAMENT

Rationing of Travelling Railway Employees

Mr. G. Mathers (Linlithgow—Lab.), on December 7, asked the Chancellor of the Duchy of Lancaster whether he would make special rationing arrangements to meet the case of railway employees in the traffic departments who were intermittently required to be away from home for periods which made the use of the ordinary or travellers' coupons inconvenient; and how he intended to meet these exceptional circumstances.

Mr. W. S. Morrison (Chancellor of the Duchy of Lancaster): I am not aware that the rationing scheme, which includes alternatively an ordinary book and a traveller's book, presents any special difficulties in the case referred to, but if the hon. member will send me particulars, I will gladly consider the matter.

Free Railway Warrants

Mr. J. Parker (Romford—Lab.), on December 7, asked the Minister of Transport whether, in view of the fact that even the return journey for single fare concession to men serving in His Majesty's forces for travelling home on leave from stations in this country involved frequently an expenditure of £2 or £3, he would consider placing a fairly low maximum on fares which men in this position would have to pay for their fares home on leave.

Captain Euan Wallace: The railway companies cannot see their way to making, at the expense of railway revenue, the extension which the hon. member suggests in the leave fare concession already given to men serving in His Majesty's Forces in this country, and I do not feel that there would be any justification for requiring them to do so. I would remind the hon. member that the men will be given, at the expense of the Departments concerned, free railway warrants for travelling on leave twice a year.

Walthamstow Railway Accident

Mr. R. W. Sorensen (Leyton, West—Lab.), on December 13, asked the Minister of Transport whether he had any information to give the House respecting the railway accident that occurred on the morning of December 7, near Wood Street Station, Walthamstow; whether he was satisfied that the existing signalling system on the railways was adequate for fog and A.R.P. diminished lighting conditions; when improved lighting for passenger coaches on the Leyton and Walthamstow lines was likely to be in complete operation; and what increase in accidents to passengers and staff had taken place during the past three months on the Leyton and Walthamstow lines.

Captain Euan Wallace: This accident occurred when the 9.35 a.m. passenger train from Liverpool Street to Chingford, which was standing at the down home signal at Wood Street, was run into by the 9.45 a.m. train travelling over the same route. One coach of the standing train was derailed and the guard and six passengers were injured. There was thick fog at the time. The circumstances attending the accident are now being investigated. Colour-light signalling is in use on the section of line in question, and I am satisfied that this type of signalling is generally adequate for operation during foggy weather. The signals are shielded from aerial observation by hoods and their brilliance has not been diminished as a result of the lighting restrictions. Some trains equipped with improved lighting will be in service on the Walthamstow line this week, and it is expected that all the rolling stock working these services will be equipped early in the new year. I am informed that 34 accidents to passengers and staff occurred on the Leyton and Walthamstow lines during the months of September, October, and November, 1938; the corresponding figure for 1939 was 45. These figures relate to all types of accidents, and the whole of the increase in 1939 is not necessarily attributable to blackout conditions.

Cheap Fare Facilities

Sir Percy Harris (Bethnal Green, S.W.—Lab.), on December 13, asked the Minister of Transport if he would consider, with the Railway Executive Committee, the possibility of a further restoration of cheap fare facilities on the railways.

Captain Euan Wallace: I am glad to inform the hon. Baronet that arrangements were made to restore, as from Monday, December 11, cheap day return bookings which were in regular operation before the war on a particular day or days in the week. This is an extension of the cheap day facilities which I was able to announce to the House on October 4, and should be of benefit to the longer distance traveller who was not covered by those arrangements. It is also proposed to reintroduce at an early date a number of cheap fare facilities applicable on certain occasions or in particular circumstances. These include occasional day tickets for special events; day tickets for anglers; tickets for patients, escorts, and visitors to convalescent homes, for relations and friends visiting or accompanying inmates of institutions for blind persons or mental deficients, and for day outings for juveniles.

Shanghai-Nanking Railway

Sir John Wardlaw-Milne (Kidderminster—C.), on December 14, asked the Prime Minister whether the Government had been able to obtain payment to British shareholders in the Shanghai-Nanking Railway of the interest due to them; and, if not, whether, in view of the fact that the railway in question had been in Japanese occupation for two years and was reported to be doing excellent business, he would press upon the Japanese Government the urgency of this matter.

The Prime Minister (Mr. Neville Chamberlain): No, Sir, but His Majesty's Ambassador at Tokyo made further strong representations to the Japanese Government on October 10 last, and will continue to press this matter as and when opportunity offers.

Footbridge at Cymmer

Sir William Jenkins (Neath—Lab.), on December 14, asked the Minister of Transport what steps he had taken to sanction the joint footbridge of the Clyncorrwg Urban District Council and the Great Western Railway Company at Cymmer, which had been condemned and found dangerous to the public; and what grant could be given to the urban council, as it was a distressed area.

Captain Euan Wallace (Minister of Transport): Application has been made by the Urban District Council for a loan for that part of the cost of the works for which it is responsible, and the matter is now under the consideration of the Minister of Health. Grants are now available from the Road Fund towards footbridges which are constructed apart from carriageways.

Irish Traffic Returns

IRELAND		Totals for 50th Week				Totals to Date			
		1939	1938	Inc. or Dec.		1939	1938	Inc. or Dec.	
		£	£		£	£	£		£
Belfast & C.D. (80 miles)	pass.	1,979	1,490	+	489	128,913	121,516	+	7,397
	goods	815	491	+	324	24,205	22,062	+	2,143
	total	2,794	1,981	+	813	153,118	143,578	+	9,540
Great Northern (543 miles)	pass.	9,300	8,350	+	950	559,200	545,950	+	13,250
	goods	15,450	10,550	+	4,900	560,650	470,700	+	89,950
	total	24,750	18,900	+	5,850	1,119,850	1,016,650	+	103,200
Great Southern (2,076 miles)	pass.	33,656	32,898	+	758	1,822,047	1,826,657	−	4,610
	goods	56,990	56,703	+	287	2,304,600	2,127,564	+	177,036
	total	90,646	89,601	+	1,045	4,126,647	3,954,221	+	172,426
L.M.S.R. (N.C.C.) (271 miles)	pass.	4,380	3,460	+	920	233,940	222,790	+	11,150
	goods	3,630	2,730	+	900	153,800	132,540	+	21,260
	total	8,010	6,190	+	1,820	387,740	355,330	+	32,410

RAILWAY AND OTHER REPORTS

Antofagasta (Chili) & Bolivia Railway Co. Ltd.—The directors regret that any payment on account of the arrears of dividend on the 5 per cent. cumulative preference stock must be deferred following approval of the scheme of arrangement for the postponement, until January 1, 1943, of partial repayment of the outstanding 5 per cent. debenture stock. This scheme provides that no dividend shall be paid on the capital stocks so long as any of the debenture stock remains outstanding.

Bengal & North Western Railway Co. Ltd.—The board proposes a final dividend of 7 per cent. and a bonus of 1 per cent. on the ordinary stock, making, with the interim dividend of 4 per cent. and bonus of 4 per cent. paid in July last, 16 per cent. for the year to September 30, 1939. Net profits, after appropriating one year's interest on reserves of £102,500, were £365,849, against £410,932 for 1937-38, when no appropriation of interest was made. For the previous year the total distribution was 18 per cent., namely, 11 per cent. dividend and 7 per cent. bonus.

Rohilkund & Kumaon Railway Co. Ltd.—A final dividend is recommended on the ordinary stock of 6 per cent., together with a bonus of 2 per cent., making, with the interim dividend of 4 per cent. together with the bonus of 4 per cent. paid in July last, 16 per cent. for the year ended September 30, 1939. Net profits, after appropriating one year's interest on reserves of £16,000, were £45,407, against £56,048 for 1937-38, when no appropriation was made. For the previous year the total distribution was 18 per cent., made up of 10 per cent. dividend and 8 per cent. bonus.

Interoceanic Railway of Mexico (Acapulco to Vera Cruz) Limited.—Gross earnings for the year 1938 of the Interoceanic System, which includes the lines of the two lessor companies (the Mexican Southern Railway Limited and the Mexican Eastern Railway Co. Ltd.), are reported from Mexico to have shown a decrease of 508,000 pesos, and operating expenses an increase of 158,000 pesos. Expenditure on maintenance of way and structures was lower, but maintenance of equipment, traffic and transportation, and general expenses were greater, due mainly to labour costs. According to the adjusted working returns received, the operating loss of the system for the year 1938 was 5,825,000 pesos, compared with 5,093,000 pesos for 1937. As a consequence of the expropriation by the Mexican Government in July, 1937, of the National Railways of Mexico (the operating managers of the Interoceanic Company's railway and leased lines) the properties of the National Company and the operation of the Interoceanic system were declared to be transferred on May 1, 1938, by Mexican Presidential Decree to the "Workmen's Administration of the National Railways of Mexico." No settlement of the claims by the Interoceanic Company against the Mexican Government in respect of revolutionary damages and of governmental retention of the properties from 1914 to 1925 has been obtained and no compensation whatever has been received.

L.M.S.R. 5 Per Cent. Preference Dividend.—The London Midland & Scottish Railway Company has decided to pay a final dividend of 2½ per cent. on the 5 per cent. redeemable preference stock, making 5 per cent. for the year, an interim of 2½ per cent. having been distributed on July 1.

Northern Ireland Road Transport Board.—The board states that although the undertaking has made marked progress during the past year, payment of the interest due on January 1, 1940, on the 4 per cent. "A" stock and the 5 per cent. "B" stock for the half-year ending December 31, 1939, has had to be deferred. Interest on the "A" stock has been paid to June 30, 1939.

Bermuda Railways Investment Co. Ltd.—The report of this company shows that the total receipts of the Bermuda Railway Company (its subsidiary) for the year to June 30 last, amounted to £56,619, against £54,953 for 1937-38, and that the operating costs rose from £45,304 to £45,666, leaving a balance of £10,953, compared with £9,649. During the year remittances amounting to £8,000 were received from the railway company and applied in reduction of the Investment Company's temporary loans. Railway operating costs were charged with expenditure on special maintenance and renewals in addition to ordinary repairs.

Mexican Southern Railway Limited.—The report for the year 1938 states that the schemes of arrangement of 1927 and 1931 provide that the net earnings of the Interoceanic System of Railways (including the Mexican Southern Company's lines) shall be pooled and the obligations of the group placed on a defined income-sharing basis for a prescribed period from January 1, 1927. The operation of the Interoceanic system for the year 1938 having resulted in a loss, no amount is receivable by the Mexican Southern Company on account of debenture interest under the schemes of arrangement.

State of Bahia South Western Railway Co. Ltd.—Gross receipts for the year to April 30, 1939, amounted in sterling to £35,234, a decrease of £5,460, and working expenses advanced by £781 to £30,093, leaving net receipts of £5,141, which were £6,241 lower. Total tonnage carried was 63,486, a decrease of 12,366 tons. Net revenue of the year is insufficient to meet the 8 per cent. interest on the prior lien debenture stock, and it is proposed to carry forward the balance of net revenue under the terms of the moratorium. A year ago 6 per cent. was paid on account of interest on this stock.

Lincolnshire Road Car Co. Ltd.—Total revenue of this company, which is controlled jointly by the L.M.S. and L.N.E. railway companies and Tilling & British Automobile Traction Limited, for the year ended September 30, 1939, was £299,126 against £281,406. After deducting all expenses and providing for depreciation, there is a balance of £33,416 (against £25,322) which, added to £10,969 brought forward, makes a total of £44,385. From this it is proposed to appropriate £10,000 (against £5,000) to general reserve, and £20,000 in payment of a dividend of 10 per cent. for the year, leaving £14,385 to be carried forward. The dividend for the previous year was at the same rate.

Moss Gear Co. Ltd.—At the ordinary general meeting of this company on December 7, Mr. Walter Duckitt, the Chairman and Joint Managing Director, said that the profits for the year to August 31, 1939, represented an appreciable increase over the previous year's figure. During the year a further small extension of the factory had been put in hand, while £37,327 had been expended on plant. The cost of machine tools had risen considerably of recent months and the company had to anticipate a continued expenditure on plant to keep the factory completely fitted for present and future requirements. They were of course carrying on their normal trade, although some disturbance in the motor component section was to be expected. The output in the present financial year was well in excess of the corresponding period of last year.

Crompton Parkinson Limited.—Net profit for the year ended September 30, 1939, was £404,903 against £402,046 in the previous year; £71,626 (against £70,546) is brought forward, making £476,529, compared with £472,592 in 1937-38. Of this, £100,591 (against £106,419) is transferred to general reserve and £5,000 (the same) to Central Benevolent Fund. After providing for the dividends on the 8 per cent. first preference and 6 per cent. preference shares (£43,658), there is a balance available of £327,280, out of which a dividend of 15 per cent. for the year is to be paid, requiring £184,416, on the ordinary and "A" ordinary shares, and a special cash bonus of 5 per cent., requiring £61,472. The £63,065 income tax recoverable from the dividends recommended above is to be utilised by transferring £38,656 to taxation account and £24,409 to general reserve, leaving £81,392 to be carried forward. Ordinary dividends are at the same rate as for the previous year but on a capital increased by £409,814, and the 15 per cent. bonus for 1937-38 was on a correspondingly smaller capital.

NOTES AND NEWS

Leopoldina Railway Moratorium.—The stockholders committee of the Leopoldina Railway Co. Ltd. has consented to an extension of the moratorium for a further year from January 1, 1940. The company has accordingly postponed until January 1, 1941, the interest on the 4 per cent. first debenture stock due on January 1 and July 1, 1937, 1938, 1939, and 1940.

Barmen - Elberfeld Railway Closed.—It is reported in a Reuters message from Amsterdam that for the first time since its opening in 1901 the Barmen-Elberfeld Railway is out of action because of "technical disturbances." This electrically worked monorail suspension line, serving a busy district in the Ruhr, was described in THE RAILWAY GAZETTE of February 9, 1934, page 242 (*Electric Railway Traction Supplement*), and its automatic signalling in THE RAILWAY GAZETTE of October 18, 1935 (page 625).

Liability on Excursion Ticket.—A verdict was given for the Great Southern Railways Company at the Dublin Circuit Court on December 6 in a case where a passenger holding an excursion ticket, claimed £1 1s. for damage to his clothes, as his trousers were ripped when he alighted at the end of his journey. Counsel for the railway contended that the company was protected under the terms of the excursion ticket issued. The fact that the passenger had not read the printed regulations on the back of the ticket did not alter the situation, which had been tested by the Supreme Court in the case of Early *v.* Great Southern Railways Company.

Two More German Railway Accidents.—The list of recent German railway accidents given on page 823 of our last week's issue must now be supplemented by two more, one in the early hours of Friday, December 22, at Genthin, 57 miles from Berlin on the Berlin-Magdeburg line, the other on the evening of the same day between Marksdorf and Kluftern, on the line between Friedrichshafen and Radolfzell, bordering Lake Constance. At Genthin a Berlin-Cologne express standing in the station, was run into by a Berlin - Frankfort - Neunkirchen express at such speed that 196 persons are reported to have been killed. The large number of casualties are said to have been due in part to the use of wooden coaches which had been pressed into service to cope with the heavy traffic and in part to the fact that both trains were crowded. Normally the second express travels to Magdeburg *via* Stendal and not *via* Genthin. Although A.T.C. is installed on this line it should be remembered that it merely reflects what the signals indicate, and that if the signals are wrongly manipulated the A.T.C. is of no avail. The accident between Kluftern and Marksdorf (about 5 miles west of Friedrichshafen) occurred when a local train and a goods train came into collision, resulting, it is reported, in the death of 99 persons.

Bengal Dooars Railway Purchase.—The directors have received notice from the India Office of the intention of the Governor-General of India in Council to purchase the company's railway and the extensions, plant, buildings, stores, rolling stock, and everything connected with it on December 31, 1940. The company has an issued capital of £760,000 (£360,000 of 4 per cent. preference stock and £400,000 of ordinary stock). It operates 161 miles of railway.

Ballingrane—Foynes Line Closing to Passengers.—The Great Southern Railways (Eire) announce that passenger trains between Ballingrane junction and Foynes will be discontinued on and from January 1. At present there are two passenger trains in each direction, and a goods train, which runs direct from Limerick to Foynes and back. The goods train will be retained. Limerick to Ballingrane is 17¼ miles, and Ballingrane to Foynes is 9½ miles, but the distance by road from Limerick to Foynes is slightly less than 20 miles. There is only one station on the branch, Askeaton. At present there is a motor-coach service between Tarbert and Foynes. Tarbert is about 12 miles beyond Foynes. This service will be discontinued and instead a new bus service will run between Limerick, Foynes, and Tarbert, and will perform the journey in approximately the same time between Limerick and Foynes as the trains which will be withdrawn. The change at Ballingrane junction into the branch train also will be avoided. There is at present one service by bus between Tarbert, Foynes, and Limerick, and by alterations of the time and by making an additional running, the substitute services can be performed economically.

G.W.R. and Third Class Sleepers.—Mr. F. R. Potter, Superintendent of the Line, Great Western Railway, in a letter to *The Times* on December 23 replied as follows to a correspondent who inquired why third class sleeping cars were not provided on night services to the West of England:—"The facts are that only recently it became possible to restore a limited amount of first class sleeping accommodation on these trains to meet the public demand. There has been very little demand for the provision of similar accommodation for third class passengers, but the company are watching the situation and will be prepared to provide third class sleeping accommodation as soon as there is sufficient demand to justify it. Throughout the Christmas season the night trains to the West of England are loaded to the maximum capacity of the engines, and the addition of even one third class sleeping car would necessitate the duplication of the trains, which is impracticable in present circumstances."

CONTRACTS AND TENDERS

The British Thomson-Houston Co. Ltd. has received an order from the South African Electricity Supply Commission for four mercury arc rectifier plants to be installed in railway substations near Durban.

It is reported that the Buenos Ayres Pacific Railway is to purchase 60 new tank wagons of 40 tons capacity each.

The India Stores Department has placed the following contracts:—

Nye and Menzies Ltd.: 10,945 bearing plates.
Guest, Keen, Williams Ltd.: 7,000 hardened spring bushes.
Heatly & Gresham Ltd.: Copper rods.
R. Wright & Partners Ltd.: Solid-drawn copper tubes.

Mather & Platt Limited has received an order from the Jaipur State Railway for six train-lighting dynamos.

Cowans, Sheldon Limited, of Carlisle, has an order for eight 3-ton and two 5-ton cranes for the Tyne Improvement Commission's new wharf extension at Tyne Dock. The hoisting motion of these cranes is powered by commutator motors in place of the more usual slip ring equipment.

The Ateliers Métallurgiques de Nivelles has received an order for two locomotive tenders from the Colombia Railways.

The Belgian National Railways have placed orders for 1,000 four-wheel tank wagons of 800 cu. ft. capacity the contractors are:—

La Brugeoise et Nicaise & Delcuve.
Ateliers Métallurgiques de Nivelles.
Soc. Anglo-Franco-Belge (La Croyère, Seneffe and Godarville).
Baume et Marpeut.
Usines de Braine-le-Comte.
Usines Ragheno (Malines).

The Bombay Baroda & Central India Railway has placed the following orders:—

Taylor Bros. & Co. Ltd.: 250 axles for carriages and wagons.
H. J. Skelton & Co. Ltd.: 45 tons of pig iron.

The South African Railways are calling for tenders for the following items and supplies:—

No. 2472 (January 15, 1940): Wheels and axles.
No. 2495 (January 18, 1940): Flat steel.
No. T.V. 29358/39 (January 11, 1940): Three pressed steel tanks with towers and fittings.

The Egyptian State Railways invite tenders for the supply of cast steel axleboxes, buffer shells, and screw couplings (E.S.R. 321.G.8/23.B: January 25, 1940); and for wire spring steel and flat steel bars (E.S.R. 307.G.8/59: January 15, 1940).

Railway Share Market

Year-end influences have prevented improvement of activity in the stock and share markets, but the undertone remained firm, and sentiment was assisted by the good tendency in British Government securities. The continued absence of news regarding plans for compensating the railways for their wartime services failed to subdue the trend in the junior stocks of the main-line companies. Although there has been no official indication that an announcement from the Government is imminent, it is being assumed in the market that it must be forthcoming during the next few weeks, otherwise a postponement of dividend decisions may prove necessary. So far the renewed upward movement in gilt-edged stocks has not been reflected in prices of debentures and prior charges of the home railways, but they were firmer than a week ago, and in most cases they are tightly held and are not always available in the market in large amounts. On the other hand, there has been a tendency for speculative activity to increase in the junior stocks, despite a fair amount of profit-taking. Attention is being drawn to the generous yields obtainable on Southern preferred, L.M.S.R. 1923 preference and L.N.E.R. first preference, if, as the market is expecting, they receive their full dividends.

Great Western ordinary at 36½, which compares with 35 a week ago, is closing the year at not far short of its highest for 1939; extreme prices during the past twelve months have been 38 and 21½. At 107 the 5 per cent. guaranteed stock was unchanged on balance for the week, and the 5 per cent. preference stock remained at 86½. On the other hand, the 4 per cent. debentures were slightly lower at 98½. L.M.S.R. ordinary, whose extremes in 1939 were 17 and 9¼, has been active around 13½, which compares with 12¼ a week ago. In the case of the 1923 preference, the highest and lowest in 1939 were 46¼ and 20, and the current price is 42, which is fractionally higher than a week ago. The 4 per cent. first preference, which touched 63½ in 1939, and has been down to 37½, is now around 58½, or slightly lower on the week. The 4 per cent. guaranteed was easier at 79, and the 5 per cent. and 4 per cent. debentures were 105 and 88 respectively. As regards L.N.E.R. stocks the first preference was firm around 37½, and is ending 1939 at approximately the highest level for the year. In regard to the second preference the year's highest and lowest have been 15 and 7⅜, and the current price is 12¼. As in the case of Southern deferred and L.M.S.R. ordinary, the market remains hopeful that a dividend of around 1 per cent. may be possible on this stock. L.N.E.R. first guaranteed at 71½ is seven points below the highest recorded in 1939, but is well above the lowest price of 60 in the past twelve months. Extremes in 1939 for the second guaranteed were 68⅞ and 47, which compare with the current price of 61½. As against a week ago, the 4 per cent. debentures at 80½ and the 3 per cent. debentures at 61 were slightly lower in price. Southern preferred, which has fluctuated during the year between 46½ and 78, has been firm this week, and at 64½ compares with 65½ a week ago. The year's extremes for the deferred stock were 19¼ and 7; the current price is 11⅞. Southern guaranteed stock at 107, and the 5 per cent. preference at 89½ were unchanged on the week, but the 4 per cent. debentures were slightly lower at 97.

Few individual features of interest developed among foreign railway securities this week. Central Argentine and Antofagasta ordinary were inclined to improve, but Leopoldina debentures were affected by the proposed extension of the moratorium. French railway sterling bonds held their recent advance.

Traffic Table of Overseas and Foreign Railways Publishing Weekly Returns

	Railways	Miles open 1938–39	Week Ending	Traffic for Week: Total this year	Traffic for Week: Inc. or Dec. compared with 1938	No. of Weeks	Aggregate Traffics to Date: Totals: This Year	Aggregate Traffics to Date: Totals: Last Year	Aggregate Traffics to Date: Increase or Decrease	Shares or Stock	Prices: Highest 1938	Prices: Lowest 1938	Prices: Dec. 19, 1939	Yield % (See Note)
				£	£		£	£	£					
South & Central America	Antofagasta (Chili) & Bolivia	834	17.12.39	22,410	+ 7,170	50	703,190	750,990	− 47,800	Ord. Stk.	14	7¼	7½	Nil
	Argentine North Eastern	753	16.12.39	ps. 143,200	− ps. 16,000	25	ps. 3,991,700	ps 4,135,200	− ps. 143,500	,,	6½	2	2⅛	Nil
	Bolivar	174	Nov. 1939	4,680	+ 1,780	48	47,530	40,100	+ 7,430	6 p.c. Deb.	8	7	7	Nil
	Brazil	—	—	—	—	—	—	—	—	Bonds.	10	4	6	85/16
	Buenos Ayres & Pacific	2,801	2.12.39	ps1,316,000	− ps65,000	23	ps. 26,764,000	ps26,473,000	+ ps 291,000	Ord. Stk.	6½	3¼	4	Nil
	Buenos Aires Central	190	21.10.39	$107,700	− $5,400	17	$1,934,600	$2,045,700	− $111,100	Mt. Deb.	15 2	8	12	Nil
	Buenos Ayres Gt. Southern	5,082	9.12.39	ps2,353,000	+ ps151,000	24	ps46,187,000	ps47,134,000	− ps 947,000	Ord. Stk.	17 5/16	8½	8	Nil
	Buenos Ayres Western	1,930	9.12.39	ps. 882,000	+ ps 8,000	24	ps16,693,000	ps15,491,000	+ ps1,202,000	,,	12 3/4	5	7	Nil
	Central Argentine	3,700	16.12.39	ps1,568,650	− ps423,650	25	ps44,792,400	ps40,968,100	+ ps 3,824,300	,,	13¼	5 5/4	7	Nil
	Do.	—	—	—	—	—	—	—	—	Dfd.	6	2½	3½	Nil
	Cent. Uruguay of M. Video	972	9.12.39	23,348	+ 4,045	24	422,181	418,907	+ 3,274	Ord. Stk.	3	1¼	2 2	Nil
	Costa Rica	188	June 1939	25,240	− 6,129	52	270,756	314,399	− 43,643	Stk.	28	22½	22½	87/8
	Dorada	70	Nov. 1939	13,700	− 600	48	150,400	178,100	− 27,700	1 Mt. Db.	105¼	104	102 2/8	57/8
	Entre Rios	810	16.12.39	ps. 242,800	− ps26,400	25	ps. 6,085,800	ps6,165,900	− ps.80,100	Ord. Stk.	7¼	3½	4	Nil
	Great Western of Brazil	1,016	16.12.39	15,300	+ 1,200	50	453,900	394,700	+ 59,200	Ord. Sh.	3/−	1/−	5/16	Nil
	International of Cl. Amer.	794	Oct. 1939	$450,759	+ $59,932	43	$4,937,141	$4,580 780	+ $356,361	—	—	—	—	—
	Interoceanic of Mexico	—	—	—	—	—	—	—	—	1st Pref.	6d.	6d.	1/2	Nil
	La Guaira & Caracas	22¾	Nov. 1939	7,055	+ 3,060	48	67 780	57,105	+ 10,675	Stk.	8	6½	7½	Nil
	Leopoldina	1,918	16.2.39	23,839	+ 1,141	50	1,070,929	1,086,500	− 15,571	Ord. Stk.	4	1	2½	Nil
	Mexican	483	21.11.39	$286,900	+ $43,800	20	$5,456,400	$5,399,400	+ $57,000	,,	1/4	1/16	1/8	Nil
	Midland of Uruguay	319	Nov. 1939	10,256	+ 715	22	44,783	43 907	+ 876	,,	7/8	1/2	1/2	Nil
	Nitrate	386	15.12.39	8,706	+ 4,229	50	119,126	137,283	− 18,157	Ord. Sh.	52/9	19 1/6	13¼	7½
	Paraguay Central	274	16.12.39	$3,188,000	− $75,000	25	$79,113,000	$76,154,000	+ $2,959,000	Pr. Li. Stk.	60	55½	40	15
	Peruvian Corporation	1,059	Nov. 1939	61,795	− 536	22	316,494	340,673	− 24 179	Pref.	5¾	1¾	2½	Nil
	Salvador	100	18.11.39	¢12,589	+ ¢214	20	¢199,896	¢239,164	− ¢39,268	Pr. Li. Db.	23	20	15	Nil
	San Paulo	153½	10.12.39	31 958	+ 5,134	49	1,539,483	1,566,698	− 27,215	Ord. Stk.	64	28	38	5¼
	Taltal	160	Oct. 1939	3,360	− 525	17	7,785	11.785	− 4,000	Ord. Sh.	1/16	1	5/8	8
	United of Havana	1,353	16.12.39	14,720	+ 521	25	411,860	381.787	+ 30,073	Ord. Stk.	3 5/8	1/2	1	Nil
	Uruguay Northern	73	Nov. 1939	1,136	− 196	22	4,781	5,231	− 450	Deb. Stk.	2	1	2	Nil
Canada	Canadian National	23,691	14.12.39	858,071	+ 152,424	50	38,737,477	34,822,208	+ 3,915,269	—	—	—	—	—
	Canadian Northern	—	—	—	—	—	—	—	— 4 p.c.	Perp. Dbs.	72	60	73	5½
	Grand Trunk	—	—	—	—	—	—	—	—	4 p.c. Gar.	104	90	98 1/2	4 1/16
	Canadian Pacific	17,171	14.12.39	625,200	+ 77,000	50	28,799,800	27,197,200	+ 1,602,600	Ord. Stk.	87/16	4¼	7	Nil
India	Assam Bengal	1,329	20.11.39	47,310	+ 535	32	978,293	938,741	+ 39,552	Ord. Stk.	81½	70	63½	4⅝
	Barsi Light	202	20.11.39	6,165	+ 3,413	32	75,562	93,187	− 17,625	Ord. Sh.	60½	54¼	45	8⅞
	Bengal & North Western	2,096	30.11.39	80,099	+ 2,384	10	412,748	455,475	− 42,727	Ord. Stk.	311	278	228	7⅞
	Bengal Dooars & Extension	161	30.11.39	5,372	+ 288	34	96,312	103,760	− 7,448	,,	89	83	87½	7 7/16
	Bengal-Nagpur	3,267	30.11.39	226.950	+ 51,082	34	5,134,155	4,531,310	+ 602,845	,,	95½	90	83½	4 15/16
	Bombay, Baroda & Cl. India	2,986	10.12.39	301,725	+ 47,400	36	6,004,950	5,952,000	+ 52.950	,,	112 7/16	95	99½	6
	Madras & Southern Mahratta	2,967	30.11.39	159,525	+ 16.852	34	3.715.405	3,621,699	+ 93,706	,,	108	97	99½	7½
	Rohilkund & Kumaon	571	30.11.39	15.843	+ 1,911	10	79 564	78 879	+ 685	,,	308	285	235	7 11/16
	South Indian	2,531¾	20.11.39	81,602	− 20,632	32	2,604,882	2,639,897	− 35,016	,,	104	101	87 1/2	5 11/16
Various	Beira	204	Sept. 1939	83,772	—	52	971,039	—	—	—	—	—	—	—
	Egyptian Delta	623	10.8.39	5,875	+ 486	19	67,548	65,905	+ 1,643	Prf. Sh.		5/6	3/4	Nil
	Kenya & Uganda	1,625	May 1939	206,557	− 11,295	21	1,220,870	1,309 332	− 88,462	—	—	—	—	—
	Manila	—	—	—	—	—	—	—	—	B. Deb.	49	41	49	7 1/8
	Midland of W. Australia	277	Oct. 1939	15,188	− 1,982	17	51,806	61,856	− 10.050	Inc. Deb.	93¾	89	88	4 9/16
	Nigerian	1,900	28.10.39	23,695	− 4,758	31	874.277	922,770	− 48,493	—	—	—	—	—
	Rhodesia	2,442¾	Sept. 1939	400.529	—	52	4,413.769	—	—	—	—	—	—	—
	South Africa	3,284	25.11.39	640,775	+ 16,340	35	22,197.873	21,188,143	+ 1,009,730	—	—	—	—	—
	Victoria	4,774	Aug., 1939	698.267	− 64.636	9	1,383,157	1,479,248	− 96 091	—	—	—	—	—

NOTE. Yields are based on the approximate current prices and are within a fraction of 1/16
Argentine traffics are now given in pesos. † Receipts are calculated @ 1s. 6d. to the rupee. § ex dividend

Diesel Railway Traction

H. F. Haworth

THE untimely death of H. F. Haworth on June 18, following an operation, will cause a feeling of deep, lasting regret among the many engineers who were fortunate enough to have known him. Not every man can turn from a tutorial occupation to become one of the best practical engineers of his day. Haworth not only did this, but revealed a remarkable aptitude for the commercial side of industry, and it was in this field that he displayed one of the finest of all his characteristics—the ability to see that not only he and his firm, but also their customer, got a square deal. The practical success of the Lysholm-Smith hydraulic transmission is due not a little to Haworth's sound sense and engineering ability. At the Leyland works he was generally called " the Doctor," but to a far more widely-spread circle of friends he was known simply as " old Haworth," a term which carried with it much affection and admiration. A spade was to him a spade, and when his firm entered the railcar field some years ago, Haworth attended numerous institution meetings on rail transport subjects, and the truculent, genial and competent way in which he attacked railway practice and prejudice invariably brought delight to his audience—and to himself. To those who got past the hurdle of his brusqueness he was kindness itself, and without any thought of material gain he would take immense trouble to help anyone with a problem or with a thirst for knowledge. He was indeed the Happy Warrior.

Italian Diesel Services

THE possession of a stud of approximately 600 railcars has enabled the Italian State Railways to accelerate radically practically every type of service on the non-electrified main and secondary lines, and even on electrified lines, for two diesel trips a day in each direction are worked between Turin and Leghorn *via* Genoa, the whole of which route is electrified on either the three-phase or high-tension d.c. systems. The various fast services are worked by the Fiat 900 b.h.p. triple-car trains or by Fiat 290 b.h.p. or Breda 230 b.h.p. single-unit cars. Except for a handful of old cars, no railcar on the State Railways is arranged for trailer haulage, and two cars are coupled together and worked in multiple-unit if traffic warrants. The Turin—Leghorn runs, with two intermediate stops, occupy 227 min. for the 218 miles, although in the northbound direction the car has to ascend the celebrated Giovi incline. The long-overdue acceleration on the Adriatic coast line has at length come through diesel traction, a railcar service connecting with the Milan train at Ancona, and running thence to Bari with three intermediate stops; the schedule is equivalent to about 52 m.p.h. in each direction. At Bari connections are made with accelerated railcar services to and from Brindisi and Taranto. Between Milan and Turin there are now four high-speed diesel runs in each direction daily, averaging 65·2 m.p.h. start-to-stop, and between Turin and Bologna there are two daily return trips by diesel cars, covering the 208·2 miles in 225-240 min. inclusive of eight intermediate stops. Another new fast diesel service is between Milan and Genoa, 93·2 miles in 90 min. southbound and 92 min. northbound, and the existing services between Bologna and Venice and Trieste, and between Bologna and Bolzano, are retained. Over secondary lines many new services with radical accelerations have been introduced, such as Milan—Tirano (connecting with the Bernina Railway); Turin—Aosta—Pré St. Didier (at the foot of the St. Bernard); Messina—Palermo; Messina—Syracuse; and even in Sardinia, where a diesel *rapido* now runs the length of the island between Cagliari and Terranova, 178 miles apart. On the small branch lines where diesels do not work all the passenger traffic there are usually two or three railcar services a day giving end-to-end speeds of anything from 30 to 40 m.p.h.

Railcar Activity in Europe

DESPITE the general trade and international situation there is no lack of interest in railcar traction, although English railways and builders can show but little activity in this field. The new A.E.C. railcars for the Great Western Railway are well under way, and the L.N.E.R. is to make tests in the Yorkshire area with the Metro-Cammell-Ganz 240 b.h.p. demonstration diesel car. In Belgium a considerable extension of 15-ton railcars of the four-wheeled type for secondary lines is likely in the near future, both on the National and Vicinaux systems. A desire to establish normal running speeds of 100 km.p.h. (62 m.p.h.) on secondary lines and 130 km.p.h. (81 m.p.h.) on principal lines has led the Italian State Railways to increase the top speed of its railcars from 90 or 110 km.p.h. (56 and 68 m.p.h.) to 120-130 km.p.h. (75-81 m.p.h.) for secondary services, and to 140-150 km.p.h. (87-93 m.p.h.) for main lines, and the accelerations noted elsewhere on this page are likely to be extended when the 100-odd diesel railcars now on order are delivered. Over 90 per cent. of the 220 railcars in Roumania are of the four-wheeled type, but most of the branch and local lines now having diesel services, attention is being turned to the main lines, and big double-bogie cars for multiple-unit working form the basis of the present construction programme. Cars of similar capacity are also to be acquired by the Jugoslav State Railways to operate fast interurban services on the standard-gauge lines, and both 300-b.h.p. bogie and 150-b.h.p. four-wheeled cars are to be ordered by the Bulgarian State Railways. The German State Railway has a big programme of high-powered cars under way, included several freight and parcels cars for trailer haulage; the Netherlands Railways have ordered 18 five-car 1,800-b.h.p. trains; the Norwegian State Railways four 1,300-b.h.p. trains for express service, and in Germany (private railways), France, Sweden, and Poland numerous railcars of low and high powers are being built.

The Improvement of Services by Railcars

The details of operation and maintenance, and resulting traffic increases and working costs

THE characteristics of railcars in providing rapid, economical, and more comfortable travel are well recognised, and the experiences of certain railways in endeavouring to regain traffic lost to the roads, or in trying to reduce operating costs are mentioned in a report made to the International Railway Congress Association by Mr. T. W. Royle, Chief Operating Manager, L.M.S.R., and Mr. F. E. Harrison, Engineer, North Eastern Area, L.N.E.R. Brief particulars are given of the G.W.R. railcars, and of the investigations the L.N.E.R. is making into the possibility of using railcars on branch lines, but more important information was supplied to the reporters by the Buenos Ayres Pacific and Madras & Southern Mahratta Railways. Other reports on the methods utilised to accelerate passenger traffic and keep down operating expenses have been compiled by Messrs. Rohde, Stroebe, and Fesser covering Central Europe and Scandinavia, and by M. Lucien Dumas, covering France, Belgium, Holland, Italy and their colonies, and other European countries. Railcar traction is given special prominence in both, and abstracts of them form the second part of this article.

Buenos Ayres Pacific

This railway has in service six bogie railcars of 240 b.h.p. and another twelve under construction; the six present cars are used for accelerated branch and inter-urban traffic, but the owning railway has suggested that future development of higher speed services will be by means of diesel-engined cars in trains or units. Wherever possible the railcars have been used to replace steam trains, but they also provide additional services not justifying the expense of steam traction. The average daily mileage of the bogie cars, including any units under repair or held as spare, is 184, with a maximum of 290 miles a day on main-line services and 382 miles a day on branch-line services. The B.A.P. Railway also has two small 120 b.h.p. Leyland-engined cars, which cover an average daily mileage of 185 on branch and secondary lines.

The rosters are arranged so that each car has four to six hours a day in the shed for inspection and any necessary maintenance work, and the cars are also kept in the depot for a 24-hr. period each week. Periodical examinations are made every three months, equivalent to a mileage of 18,500 to 20,000. Three to five days are allowed for this periodic examination and overhaul. Major examinations and overhauls are given every 75,000 miles or so, which means about 15 working days out of service. The availability of the railcars in service, excluding the time taken by a general overhaul, has been of the order of 92 per cent. The railcars are maintained and shedded at particular depots, and are not moved about from place to place. The B.A.P. has estimated the life of the railcar components as:

	Miles
Engines (Ganz type)	600,000
Transmission (mechanical and hydraulic types) ..	900,000
Bogies and running gear	1,125,000
Bodywork and interior	1,500,000

This railway expects to standardise a 240/275-b.h.p. bogie railcar with a power-weight ratio of at least 6·5 b.h.p. per ton for branch-line operation, but the same general design could be used for main-line traffic with a top speed of 75 m.p.h. in place of the 56 m.p.h. for branch-line work. (The double-bogie cars of 240 b.h.p. now at work were described in the issue of this Supplement for February 18, 1938.)

Madras & Southern Mahratta

This Indian line uses half-a-dozen broad-gauge diesel-electric railcars, which were introduced on branch lines in order to cope with road transport competition by more economical and speedier working, and the experience has been that the replacement of steam trains by these cars does substantially reduce the operating costs, as indicated by the attached table. On the Cocanada—Somagundam branch line the railcars have cut the steam train time from 99 min. to 87 min. for the 29 miles, and including 14 intermediate stops against the seven made by the steam trains. This particular branch was opened in 1929 and the working expenses have never been fully met by the receipts. The goods traffic turned out to be negligible, and there has been, and is, intense road competition. The passenger-traffic density was 200,000 per mile per annum in 1930, and mainly as a result of bus competition this figure had fallen to 93,000 just before the introduction of the railcars. For the first six months the railcars were operated without any reduction in fares, but by reason of their economical working it was then found possible to reduce the fares, and this, combined with the faster and fairly frequent service, has increased the number of passengers carried by 43 per cent.

ECONOMY GAINED BY RAILCAR OPERATION, COCANADA-KOTIPALI BRANCH, M. & S.M.R.

Year	Passenger Density	Working Expenses	Net Deficit on Branch
1934–35	100	100	100
1935–36*.. ..	122	173	52
1936–37†.. ..	136	64	30
1937–38	143	59	21

* Railcars introduced during this year.
† Fares reduced during this year.

The six Armstrong-Whitworth diesel-electric cars in traffic are shedded at one depot, and work services on main and branch lines aggregating 836 miles a day; one car out of the six is normally regarded as spare. The cars can be run solo or in multiple-unit, but are not used for trailer haulage. Six hours each week are devoted to the inspection and maintenance of each car, in addition to any work which may be needed urgently and carried out between turns of duty, and the engine is inspected every two or three weeks. The mileage between each light overhaul of the engine is 20,000 to 25,000. The company emphasises that careful maintenance is necessary to get the best results, and that the cars should be shedded at one place, instead of having single cars or two cars at a number of widely-separated places. The M. & S.M. also refer to some of the incidental savings of railcar traction, *e.g.* if a new halt is required, it need consist only of a short platform, instead of one extending the full length of the longest train on the particular line; higher speeds can

be sanctioned over lightly-laid lines because of the lighter axle loads; and if railcars can entirely take the place of steam trains, the track upkeep is less costly. (The Madras & Southern Mahratta railcars were described in the issues of this Supplement for January 25 and February 22, 1935).

There is a considerable field for railcars in India, but it is essential to find a railcar of low initial and running costs which can be operated for the conveyance of traffic at very low fares, in order to compete with the bus routes.

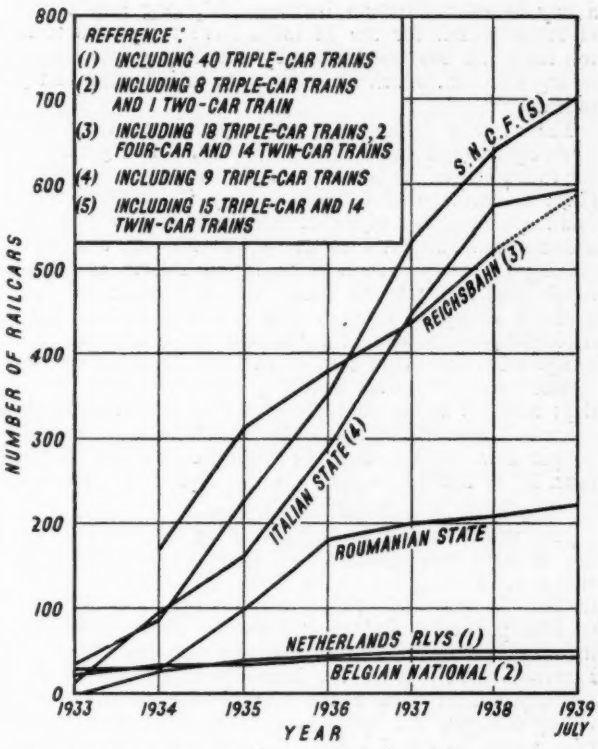
Central Europe and Scandinavia

The utilisation of railcars is considered to have been thoroughly justified economically, and is recognised to have given a great impetus to the acceleration of steam and electric trains. The economy of railcars is quite beyond question, and reliability nowadays is almost entirely a question of efficient maintenance and repair methods. In Germany and elsewhere railcars now work all the passenger traffic on a number of branch lines served only by stopping trains. The proportion of the total passenger train services operated by railcars is 41 per cent. in Denmark, 22 per cent. in Hungary, 8 per cent. in Norway, and 7 per cent. in Germany.

On the German State Railway the railcar stud has increased from 172 vehicles in 1934 to 440 in 1937 and 524 in 1938, these totals excluding steam and electric-battery railcars. The total passenger train mileage over the same period increased by 28·5 per cent., but the increase in railcar mileage is of the order of 275 per cent., and the average yearly mileage per railcar has risen by 35 per cent. The *schnelltriebwagen* average 1,100 km. a day per set in traffic and the other railcars 600 km. on important lines and 350 km. on secondary lines. About 30 per cent. or so of the whole railcar stud is under repair or being held in reserve at any given time. The reporters emphasise that the introduction of railcars should not be carried out timidly.

A number of the factors which cause a railcar to be withdrawn from traffic are dependent upon the mileage run, for example, brake inspections and adjustments, and the re-turning of tyre profiles. These are the reasons why high-speed railcars need more frequent periodic visits to the repair depot than cars engaged in less arduous service with a lower mileage, and it may also help to explain what may seem a high proportion of cars under repair or held in reserve in certain cases. It is the practice in Germany to make up a train of a number of motor-coaches and trailers, but except on secondary lines all the trailers are of the driving type. If there are more than two railcars in the formation, an assistant driver is carried, and in both Germany and Denmark an assistant driver is carried when two or more of the high-speed train sets are coupled in multiple-unit. In Germany, at least, it is considered that the long distances run non-stop at really high speed justify such a measure, as well as giving added security from partial failures due to trifling causes. The Reichsbahn has in view a programme of unification of multiple-unit control systems, so that diesel-electric or diesel-hydraulic railcars or train sets of medium and high powers can be coupled together indiscriminately and operated by one man.

Where possible, a power-weight ratio of 10 b.h.p. per ton is favoured in Germany, but considerations of maximum passenger comfort have prevented this being realised in all designs. Generally the weight per seat is 650 to 880 lb. in four-wheel cars and 850 to 1,200 lb. in bogie cars, but one small car in Sweden has a ratio of only 440 lb. per seat. From information supplied by various railway administrations, the reporters conclude that of



Graph showing the increase in the number of railcars in important European countries in the last six years

the total running expenses of railcars, wages account for 15 to 30 per cent., fuel and other materials for 10 to 25 per cent., maintenance and repairs for 30 to 40 per cent., and interest and depreciation for only 10 to 15 per cent. With only one driver the wages cost may be only one-third of that found in steam traction, and in any case never appears to rise above 50 or 60 per cent. of the steam figure. Under conditions not particularly favourable to railcars, the running expenses per mile can be cut by about 37 per cent. on the steam traction cost, but in favourable applications railcars may handle the traffic at only one-half to one-quarter the cost of steam haulage.

France, Belgium, Holland and Roumania

A considerable acceleration and increase in frequency as a result of using railcars appears to be general in the countries covered by the report of M. Dumas. For example, the use of twin and triple diesel formations on the Belgian National Railways has enabled the overall speeds between Brussels and such towns as Ghent, Charleroi, Namur, Mons and Liége to be increased by anything from 5 to 22 per cent., although in no case does the distance exceed 62 miles. In Italy, fast railcars now run from Turin to Leghorn in 227 min. inclusive of two stops, compared with about 300 min. with a combination of steam and electric traction. On important interurban services in Roumania an overall speed of 54 m.p.h. is maintained by bogie railcars, this being an increase of something like 20-30 per cent. compared with steam. The gain of over 50 per cent. in time resulting from the use of railcars on the Biskra—Touggourt metre-gauge line in Algeria was recorded in the last issue of this Supplement, and savings of 20-22 per cent. have been effected in Tunisia by the use of railcars on standard-gauge routes. On the Yunnan Railway five railcar trips

a day in each direction between Haiphong and Hanoi in 115-135 min. for the 64 miles have recaptured from the roads all the traffic lost by the single steam train taking 170 min. which ran before the introduction of the railcars.

The average distances covered by railcars vary considerably according to local requirements. The eight triple-car trains of the Belgian National Railways, for example, cover an average of 430 km. a day inclusive of three sets normally under repair or in reserve; the 40 triple-car trains in Holland cover an average of 400 km. a day including the 15 per cent. normally in reserve or under repair; and under similar conditions the Renault twin sets shedded at Lyons average 294 km. a day, the Nord triple-car sets shedded at Paris, 464 km. a day, the 600 b.h.p. Decauville cars centred at Grenoble and working almost exclusively over heavily-graded lines, 241 km. a day; and the whole stud of more than 200 cars on the Roumanian State Railways, 220-230 km. a day, although 90 per cent. of the cars are four-wheelers and 15 per cent. is the normal proportion under repair or in reserve.

Traffic Increase

Just what increase in traffic can be attributed to the use of railcars is often difficult to determine because of extraneous factors, but on the Paris—Rouen line the introduction of systematic railcar services led to an increase of 20·2 per cent. in the number of tickets sold, the increase in train mileage being 18·8 per cent. On the Lyons—Grenoble route the introduction of four supplementary railcar trips a day did nothing to retard the falling receipts, but by increasing the number of railcar trips a day to 33, 42, and 46, with a reduction in the number of steam trains, the passenger receipts rose by 2, 8¼, and 13½ per cent. respectively. An 11 per cent. increase in revenue followed the substitution of five daily return railcar trips between Pontarlier and Gilley for three steam trips, and a 33 per cent. increase in passenger-miles followed an increase of 41 per cent. in the train-miles by the use of railcars on the Compiegne-Roye section of the French National Railways. In all cases the use of railcars enabled the services to be accelerated. The Roumanian State Railways consider that increases in the number of passengers up to 50 per cent. on lines of light traffic have resulted from the introduction of railcars. On the Yunnan Railway, passenger receipts rose from $40,561 in 1933—the last full steam year—to $137,612 in 1938 when five return railcar trips were being operated.

The operating costs of the diesel trains invariably are less than those of steam trains on a mileage basis, but they are not always so on a seat basis. However, the diesel usually makes a greater mileage and runs more frequent trips than the steam train. The average operating cost of certain triple-car trains in France is 17·3 fr. per km. compared with 22·45 fr. per km. of steam trains with twice the number of seats, but the diesels operate at speeds up to 87 m.p.h. whereas the steam trains do not exceed 75 m.p.h. In Tunisia, 78-seater diesel railcars cost 4·49 fr. per km. to operate compared with 12·6 fr. per km. of steam trains with 208 seats. Express railcars in Italy cost 2·67 lire per km. to operate compared with a figure of 7·98 lire per km. for a six-coach steam train, but on normal services a 56-seater railcar costs 2·35 lire per km. to operate against the 4·92 lire per km. of a two-coach train and steam locomotive. The average operating cost of the 160-seater triple-car diesel-electric trains operating fast services on the Netherlands Railways is 0·38 fl. per km. compared with 0·81 fl. per km. for a steam train of four coaches and a van having 300 seats. On the Netherlands Railways is an extensive electrified system with modern two-car and three-car streamlined electric trains having mechanical portions based on the design of the diesels; the operating cost of a five-car formation composed of one three-car set and one two-car set with 312 seats is 0·579 fl. per km. without any allowance for the charges on the fixed equipment of the electrified lines.

TRAIN OPERATING COSTS, NETHERLANDS RAILWAYS

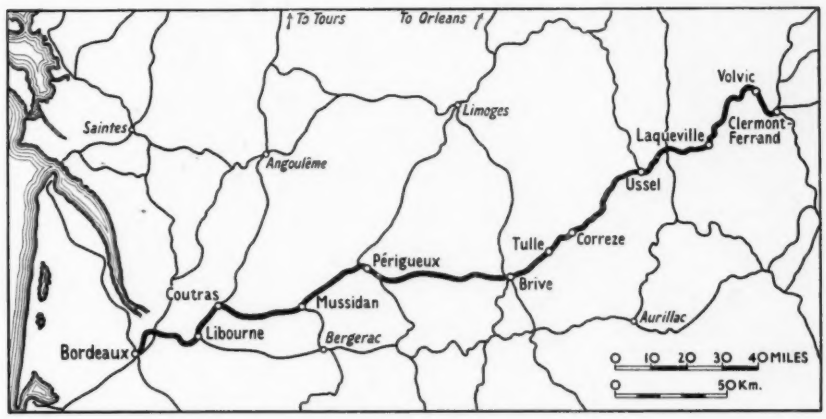
—	Triple-car diesel train, 820 b.h.p. 160 seats	Steam train with one locomotive, four carriages, and one van. 300 seats
Per km.	Dutch florins	Dutch florins
Driving crew wages ..	0·030	0·141
Fuel	0·035	0·144
Overhead charges (management)	0·036	0·107
Lubrication and materials..	0·020	0·003
Maintenance and repairs ..	0·125	0·183
Guard and traffic dept. wages	0·037	0·140
Amortisation	0·098	0·095
Total per train-km. ..	0·381	0·813
Initial cost	195,000	238,000
Distance or time used for amortisation charges	7 years for engines, 15 years for transmission, 20 years for mech. portion	25 years for locomotive, 20 years for train
As percentage of operating cost :		
All crew wages	17½	34½
Maintenance and repair..	33	22½
Amortisation	25½	12

TRAIN OPERATING COSTS, BELGIAN NATIONAL RAILWAYS

—	Triple-car diesel train, 730-820 b.h.p. 229 seats	Steam train with one Pacific locomotive and three coaches. 274 seats
Per km.	Belg. fr.	Belg. fr.
Driving crew wages ..	0·38	1·22
Fuel	0·94	2·48
Overhead charges (management)	0·26	0·26
Lubrication and materials..	0·25	0·11
Maintenance and repairs ..	4·59	3·37
Guard and traffic dept. wages	0·80	0·80
Amortisation	2·56	1·14
Total per train-km. ..	9·78	9·38
Initial cost	5,825,000	2,736,000
Distance or time used for amortisation charges	1,340,000 km. for power plant, 4,000,000 km. for mech. portion	33 years for locomotive, 40 years for train
As percentage of operating cost :		
All wages	12	21
Maintenance and repair..	47	36
Amortisation	26	12

Long-Distance Cross-Country Service in France

Some notes on the vehicles used, and their performances, on the Bordeaux to Clermont-Ferrand line, crossing the Massif Central at a height of over 3,000 ft.

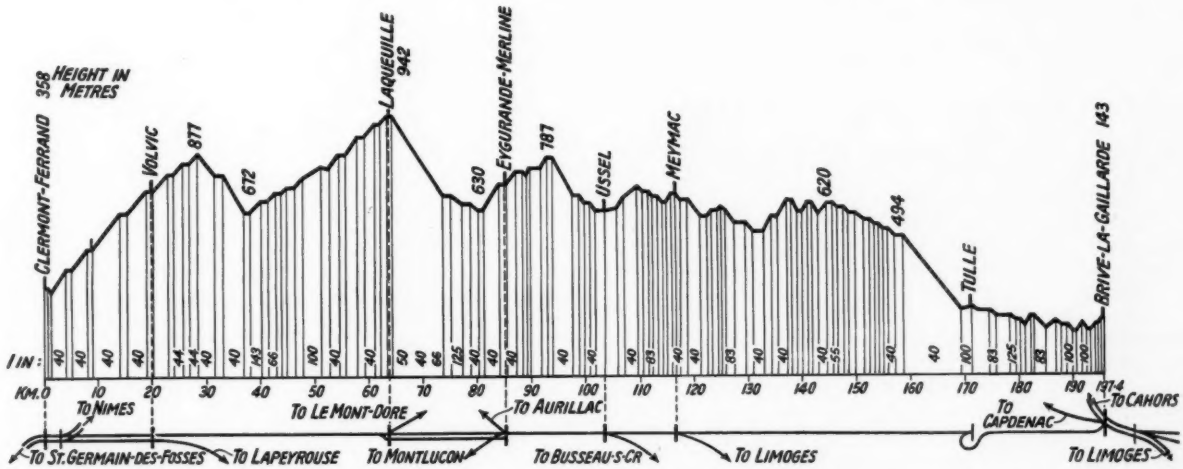


Map showing the relation of the Bordeaux to Clermont-Ferrand line to the north-south lines

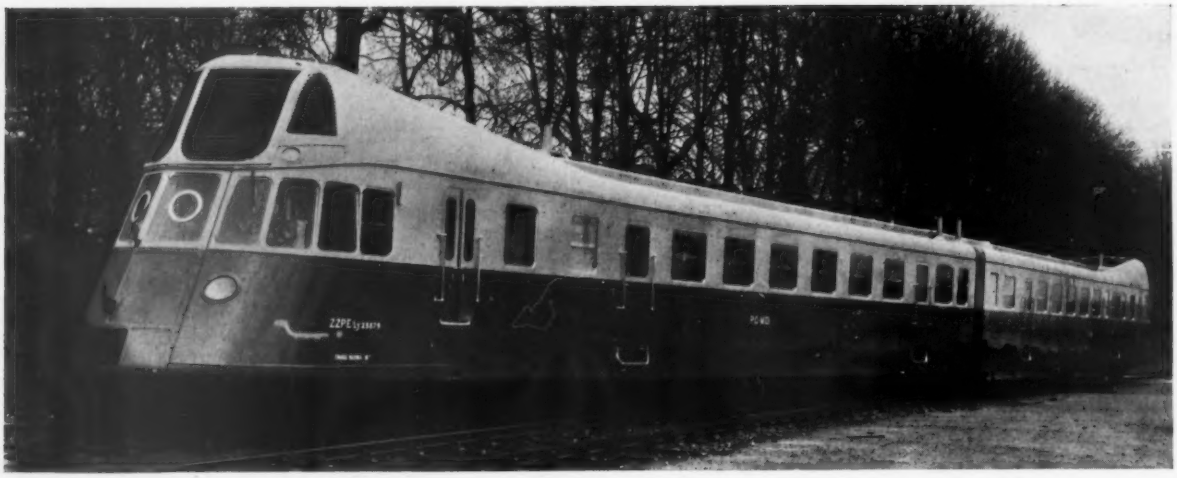
ONE of the most notable of the long-distance cross-country railcar services in France is that between Bordeaux and Clermont-Ferrand, a distance of 246 miles, about half of which is over heavy grades and ranging up to a height of over 3,000 ft. above sea-level. It is worked by Renault bogie cars of 265 and 300 b.h.p. and by Renault twin-articulated cars of 530 b.h.p., and the stud of these vehicles shedded at Bordeaux also operates subsidiary services on the Bordeaux—Bergerac route and between Bordeaux, Périgueux, Brive and Tulle on the Clermont-Ferrand route.

There is one through service a day in each direction, worked by the same car, but the duties of the cars in the link at Bordeaux vary from day to day over a weekly period. Another daily return trip over the same line is between Tulle and Bordeaux, a distance of 140 miles, leaving Tulle at 6.35 and reaching Bordeaux (St. Jean) at 10.05 and departing again at 17.36 to reach Tulle at 20.55. The through Clermont-Ferrand service leaves Bordeaux at 7.20 and arrives at Clermont-Ferrand at 13.59; the car is taken to the shed there and inspected, and begins the return journey at 16.30, arriving back at Bordeaux at 23.10.

Four districts of the French National Railways are passed through on the journey, *viz.* Bordeaux, Périgueux, Brive-la-Gaillarde, and Clermont-Ferrand. The Bordeaux district extends to Périgueux, and between Bordeaux and Coutras the electrified tracks of the main line to Tours are used. The grades here do not exceed 1 in 143 and there are many long straight stretches of line. Onwards to Brive the gradients increase to 1 in 100 and curves are more numerous, but from Brive on to Clermont-Ferrand the line has the characteristics of a mountain railway, with a summit 3,090 ft. above sea-level, long grades of 1 in 66 to 1 in 40, and continuous S-curves of 240, 250 and 300 m. radius on the steepest grades. Coming west out of Clermont-Ferrand the line rises unbrokenly, except for the station levels, at 1 in 40 to Le Vauriat, climbing in this distance of 18 miles from 1,077 ft. to 2,875 ft. above the sea. There is one



Gradient profile and track diagram of the Brive—Clermont-Ferrand hill section of the Bordeaux to Clermont-Ferrand cross-country line



One of the 600-b.h.p. 127-seater twin-articulated diesel-mechanical Renault trains used in Central France

reversing station on the line, at Tulle, situated at the western foot of the mountain section.

From Bordeaux to Périgueux the general speed limit is 110 km.p.h. (68 m.p.h.) and this is maintained easily by both the single and twin-unit railcars. Between Périgueux and Brive the general limit is 90 km.p.h. (56 m.p.h.) with special limits of 85 km.p.h. (53 m.p.h.) approaching Périgueux and 60 and 70 km.p.h. (37 and 43 m.p.h.) approaching Brive. On certain runs the *autorails* are allowed a general limit of 100 km.p.h. (62 m.p.h.). Much more stringent restrictions are in force between Brive and Clermont-Ferrand, due mainly to the sinuous route; the general limit for railcars between Brive and Ussel is 80 km.p.h. (50 m.p.h.) with several restrictions to 70 km.p.h. (43 m.p.h.) and one to 30 km.p.h. (18½ m.p.h.). Down the long 1 in 40 grade from the summit at Laqueuille to the eastern terminus at Clermont-Ferrand speed is limited to 70-75 km.p.h. (43-46 m.p.h.) uphill and downhill. A gradient profile and track diagram of the mountain section east of Brive form part of this article, and from them will be appreciated the effect of such speed restrictions in preventing a high overall average.

Over the straight and generally level section between Bordeaux and Coutras both single and double cars maintain 95-105 km.p.h. (59-65 m.p.h.) easily in fourth gear with the engine running at about 1,200 r.p.m. and the throttle at half to two-thirds open. From the station stops the schedules call for accelerations of the order of zero to 10 km.p.h. (6·2 m.p.h.) in 8 to 9 sec.; to 20 km.p.h. (12·4 m.p.h.) in 17 sec. (over points and crossings); to 30 km.p.h. (18·5 m.p.h.) in 26 sec.; to 50 km.p.h. (31 m.p.h.) in 47 sec.; and to 60 km.p.h. (37 m.p.h.) in 60-62 sec. Even with the 265 b.h.p. single-unit cars the power is more than sufficient to enable this rate of approximately 1·0 km.p.h.p.s. to be maintained easily, and on certain occasions an acceleration of the order of 1.0 m.p.h.p.s. is maintained up to 27-30 m.p.h.

On a recent east-bound journey with one of the 265 b.h.p. single-unit Renault cars taring 30 tons and having a fairly full load of passengers and luggage we maintained a steady 80 km.p.h. (50 m.p.h.) up the 1 in 143-145 east of Périgueux, and fell only to 70 km.p.h. (43½ m.p.h.) at Limeyrat summit after the grade had steepened to 1 in 100; up the entire grade the car was operated in top (fourth gear) and with the throttle only half open, the engine speed being about 1,000 r.p.m. at 80 km.p.h. (50 m.p.h.) and about 875 r.p.m. at 70 km.p.h. (43 m.p.h.). The top engine speed of 1,500 r.p.m. corresponds to a track speed of 120 km.p.h. (75 m.p.h.) when the car is operating in top gear.

Up the 1 in 40 grade from Tulle the car was operated in second gear all the way, changing to third on the slightly easier grades just before Correze. The start-to-stop time for the 16·87 km. (10·45 miles) from Tulle to

EXPRESS RAILCAR TIMETABLES, BORDEAUX TO CLERMONT-FERRAND

Distance, km.	Time	—	Station	—	Time	Distance, km.
0	7.18	dep.	Bordeaux (St. Jean)		23.10	397
41	7.46	dep.	Libourne		22.42	356
52	8.00	dep.	Coutras	dep.	22.30	345
127	8.56	arr.	Périgueux	dep.	21.32	270
	8.58	dep.		arr.	21.30	
180	9.45	arr.	Terrasson	dep.	20.43	217
	9.46	dep.		arr.	20.42	
199	10.03	arr.	Brive	dep.	20.27	198
	10.05	dep.		arr.	20.25	
225	10.31	arr.	Tulle	dep.	19.59	172
	10.34	dep.		arr.	19.57	
242	10.58	dep.	Correze	dep.	19.37	155
293	11.55	arr.	Ussel	dep.	18.37	104
	11.56	dep.		arr.	18.35	
311	12.17	arr.	Eygurande	dep.	18.15	86
	12.18	dep.		arr.	18.14	
333	12.42	arr.	Laqueuille	dep.	17.51	64
	12.43	dep.		arr.	17.50	
377	13.32	arr.	Volvic	dep.	17.00	20
	13.33	dep.		arr.	16.59	
397	13.59	arr.	Clermont-Ferrand ..	dep.	16.30	0

LOG OF 265-B.H.P. RAILCAR RUN UP 1 IN 40 GRADE, S.N.C.F.

Height above sea, Metres	Distance, km.	——	Min. sec.	Speed, km.p.h.	Curve radius, metres	
212·7	0·00	Tulle .. dep.	0 00	—	—	
		598 km.p. ..		35		
		599 „ ..	—	42	—	
		600 „ ..	—	43	500	
		601 „ ..	—	43	—	
		602 „ ..	—	42	300	
		603 „ ..	—	43	300	
		604 „ ..	—	43	290	Transmission in second gear ; engine speed 1,175 to 1,300 r.p.m.
		605 „ ..	—	44	250	
		606 „ ..	—	41	250	
		607 „ ..	—	40	240	
		608 „ pass.	15 09	44	290	
		609 „ ..	—	44	—	
493·7	12·62	Gimel (609·7 km.p.) pass.	17 16	45	500	
		610 km.p. ..	—	45	—	
		611 „ ..	—	45	352	
		612 „ ..	—	64	—	Transmission in third gear.
		613 „ ..	—	55	497	
555·0	16·875	Correze .. arr.	22 31	—	—	

Correze was 22 min. 31 sec. against the schedule of 24 min., and equivalent to an average of 27·9 m.p.h. The car moved slowly out of Tulle station through the junction and took 1 min. 55 sec. to accelerate to 40 km.p.h. (25 m.p.h.), but thereafter went up the continuously-curved 1 in 40 at a steady 42-44 km.p.h. (26-27½ m.p.h.) with one momentary drop to 40 km.p.h. (25 m.p.h.) on the section with the sharpest S-curve, 240 m. (790 ft.) radius; the remainder of the route from Tulle to Gimel is curved almost continuously at 250-300 m. (820-985 ft.) radius and between Gimel and Correze at 350-500 m. (1,150-1,640 ft.) radius. On the easier grades near Correze a momentary maximum of 64 km.p.h. (39·7 m.p.h.) was attained. The accompanying log can be read in conjunction with the gradient profile to gain an idea of the performance of the car between Tulle and Correze; the heights above sea-level of these two stations are 700 ft. and 1,800 ft. respectively.

Up the final bank at 1 in 66-40-50 to the summit of 3,090 ft. at Laqueuille, the car, here in a snowstorm, increased its speed from 45-46 km.p.h. (28-29 m.p.h.) to 50 km.p.h. (31 m.p.h.) on running from the 1 in 40 on to the 1 in 50 grade. Up the subsidiary 1 in 40 section leading from Pontgibaud to Le Vauriat (2,270 to 2,875 ft. above sea-level) the car was worked in second gear as far as St. Ours, and maintained 42-44 km.p.h. (26-27½ m.p.h.) round continuous curves of 250-300 m. (820-985 ft.) radius. At the short station level stretch the gear was changed to third and the throttle opened nearly full; the speed immediately rose to 50 km.p.h. (31 m.p.h.) and did not fall below 45 km.p.h. (28 m.p.h.) up the ensuing 3 km. (1·86 miles) to Le Vauriat, the engine running at 800-820 r.p.m. with the throttle wide open. In the westbound direction speeds of 42-44 km.p.h. (26-27½ m.p.h.) are normal up the longer 1 in 40 grade leading out of Clermont-Ferrand and ending at Le Vauriat (29 km.p.).

New Twin-Power Vehicle

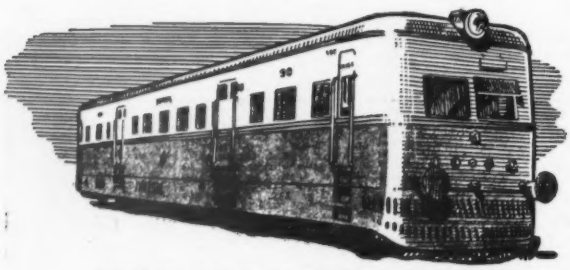
The first of a new type of two-power railcar is undergoing its tests in France, and will shortly be introduced into passenger service on the line between Bordeaux and Périgueux. It comprises a bogie vehicle with a double-unit diesel-electric power plant, and carries a pantograph and control gear so that the traction motors can be fed with current from the overhead contact line when operating on electrified lines. On the Bordeaux—Périgueux service it will work over the 1,500-volt d.c. Tours—Bordeaux electrified section between Bordeaux and Coutras, 32½ miles, and thence to Périgueux, 46½ miles, and on certain schedules across central France to Clermont-Ferrand, under diesel power.

Railcar for operation either on diesel power, or on 1,500 volts d.c. with overhead current collection, French National Railways

This new railcar, as well as a second of the same type which is to be given its trials shortly, was built by the Soc. Alsthom, and is equipped with two Alsthom-Ganz engines each set to give 250 b.h.p. at 1,300 r.p.m. and each coupled to a 150 kW variable-voltage generator having an overhung auxiliary generator of 9 kW capacity. There are two nose-suspended traction motors on the bogie at the end of the car remote from the diesel engines. The car is 84 ft. long and contains a 9-ft. baggage room, a postal compartment, a lavatory, 73 seats, an engine room, and two driving compartments. Trailers are hauled when necessary, and they and the passenger saloon of the railcar are heated by an oil-fired La Mont boiler providing 220 to 265 lb. of heating steam an hour.

FRENCH COLONIAL RAILCARS.—The Madagascar Railways now have in traffic on metre-gauge lines two double-engined railcars each hauling one special trailer. Power is provided by two Saurer six-cylinder engines having a maximum output of 180 b.h.p. each, and driving the wheels through an electric transmission system with four traction motors. A car and trailer weigh 42 *tonnes* loaded, and have accommodation for 54 seated and 30 standing passengers. A top speed of 53 m.p.h. is allowed, and 34 m.p.h. can be maintained up grades of 1 in 67. On the Réunion lines a double-engined car of the same power and type hauls two trailers, the set weighing 72 tons and having 44 seats and 58 standing places, in addition to freight and parcels space.

NORTH WESTERN RAILWAY
DIESEL RAIL CAR



TRAVEL BY DIESEL RAIL CARS

The North Western Railway will inaugurate a new quick comfortable and convenient service for third class passengers by a fleet of Diesel Rail Cars from May 15th. The cars will chiefly operate between Jullundur City and Hoshiarpur, Kapurthala, Tanda Urmar, Dasuya, Lohian Khas; between Amritsar and Narowal, Qadian, Batala, Gurdaspur; and between Ferozepore-Moga Tahsil-Jagraon-Ludhiana, Ferozepore-Bhatinda-Dhuri-Sangrur. One of the cars will also pay a daily visit to Lahore, arriving at 15-56 from Amritsar and leaving at 16-4 for Jullundur City.

These rail cars will give the travelling public a quick modern service between these important points, a service which it is hoped will be most popular. The following are the Abstract timings for these cars which will come into force from May 15th.

BETWEEN JULLUNDUR CITY AND HOSHIARPUR.

		dep.		arr.	dep.		arr.
Rail Car Jullundur City		5-30	Hoshiarpur	6-38	6-43	Jullundur City	7-47
"	"	6-53	"	7-58	8-04	"	8-4
"	"	8-06	"	9-14	9-54	"	9-10
"	"	9-20	"	10-42	10-50	"	11-52
"	"	12-3	"	13-5	13-14	"	14-16
"	"	14-38	"	15-37	15-47	"	16-49
"	"	16-38	"	16-1	16-11	"	19-13
"	"	19-35	"	20-28	20-43	"	21-43

BETWEEN JULLUNDUR CITY, KAPURTHALA AND TANDA URMAR.

		dep.		arr.	dep.		arr.
Rail Car Jullundur City		7-50	Kapurthala	7-58			
"	Kapurthala	7-39	Tanda Urmar	8-54	9-5	Kapurthala	10-27
"	"	10-47	"	12-22	12-32	"	13-33
"	"	14-6	"	15-33			

BETWEEN TANDA URMAR—JULLUNDUR CITY—DASUYA—LOHIAN KHAS

		dep.		arr.	dep.		arr.
Rail Car Tanda Urmar		15-46	Jullundur City	16-50	16-53	Dasuya	18-29
"	Dasuya	18-55	Lohian Khas	21-15			
"	Lohian Khas	7-30	Jullundur City	9-31			

BETWEEN JULLUNDUR CITY AND AMRITSAR

	dep.		arr.
Rail Car Jullundur City	8-50	Amritsar	10-15

BETWEEN AMRITSAR AND NAROWAL.

		dep.		arr.	dep.		arr.
Rail Car Amritsar		12-45	Narowal	13-45	13-5	Amritsar	14-47
"	"	15-0	"	16-45	16-35	"	18-06

BETWEEN AMRITSAR—BATALA AND QADIAN.

		dep.		arr.	dep.		arr.
Rail Car Amritsar		19-15	Qadian	20-40	20-50	Amritsar	22-0
"	"	4-35	"	5-53	6-3	Batala	6-27
"	Batala	6-44	"	7-8	7-18	Amritsar	8-05
"	Amritsar	9-15	"	10-35	10-45	Batala	11-0

BETWEEN BATALA—GURDASPUR, QADIAN—LAHORE AND JULLUNDUR CITY.

		dep.		arr.	dep.		arr.
Rail Car Batala		17-19	Gurdaspur	18-0	18-10	Batala	18-51
"	"	13-7	"	13-47	13-55	"	14-23
"	"	14-45	Qadian	15-10	15-25	"	15-51
"	"	16-36	"	16-51	17-3	Lahore	19-30
"	Lahore	20-6	Jullundur City	23-30			

BETWEEN JULLUNDUR CITY—LUDHIANA—FEROZEPORE—BHATINDA—DHURI AND SANGRUR.

		dep.		arr.	dep.		arr.
Rail Car Jullundur City		6-30	Ludhiana	7-45			
"	Ludhiana	8-0	Ferozepore Cantt.	11-38	11-45	Bhatinda	13-10
"	Bhatinda	13-30	"	15-31	15-40	Ludhiana	18-16
"	Ludhiana	19-30	"	22-16			
"	Ferozepore Cantt.	5-15	Bhatinda	7-20	7-35	Sangrur	10-21
"	Sangrur	10-38	Ludhiana	12-15	14-10	Moga Tahsil	15-25
"	Moga Tahsil	15-45	"	17-10	18-5	Jullundur City via Nakodar	20-15

BETWEEN JULLUNDUR CITY—DHURI—PATIALA—BHATINDA AND RAIWIND.

		dep.		arr.	dep.		arr.
Rail Car Jullundur City		7-5	Ludhiana	8-19	8-29	Dhuri	9-58
"	Dhuri	11-5	Patiala	12-10	13-10	Bhatinda	16-35
"	Bhatinda	17-5	Ferozepore Cantt.	18-53	18-59	Raiwind	20-50

BETWEEN RAIWIND—FEROZEPORE CANTT.—MacLEOD GANJ ROAD—NAKODAR—LOHIAN KHAS — JULLUNDUR CITY

		dep.		arr.	dep.		arr.
Rail Car Raiwind		4-50	Ferozepore Cantt.	6-0*	6-5*	MacLeod Ganj Road	9-32
"	MacLeod Ganj Road	11-4	Nakodar	16-39	16-49	Lohian Khas	17-15
"	Lohian Khas	17-35	Jullundur City	19-10			

In consequence of the introduction of the above services following changes in timings of trains will also be made from the same date

Train No.		Station from	dep.	Station to	arr.
630	Down	Jullundur City	13-40	Tanda Urmar	14-7
604	Down	Jullundur City	19-20	Makerian	21-30
605	Up	Shegpur Siwal	15-15	Jullundur City	16-15
267	Up	Hoshiarpur	14-35	Jullundur City	15-15
268	Down	Jullundur City	7-20	Hoshiarpur	9-35
194	Down	Jullundur City	20-35	Hoshiarpur	21-50
208	Down	Hajikha	13-3	Narowal	20-5
209	Up	Qadian	13-50	Amritsar	14-0
422	Up	Jallalabad	13-30	Chahlana	15-25
424	Down	MacLeod Ganj Road	13-14	Ferozepore Cantt.	15-45
426	Down	Jallalabad	7-33	Ferozepore Cantt.	9-50
201	Up	Jullundur City	17-40	Kapurthala	18-14
288	Up	Jullundur City	12-0	Fujian	13-5

The service on the Jullundur City-Hoshiarpur and Batala-Qadian sections will consist of Diesel Rail Car and train services mentioned above besides 183 up between Hoshiarpur and Jullundur City and 310 down between Batala and Qadian which will continue to run as at present.

The following trains and Sentinel Coaches will come off due to Diesel Rail Car services provided on Ferozepore Cantt.-Ludhiana, Jullundur City-Lohian Khas, Dhuri-Ludhiana and Dasuya-Jullundur City sections:

310 down and 419 up between Ferozepore Cantt and Ludhiana.

71 up and 73 down Sentinel Coaches between Jullundur City and Lohian Khas.

207 up and 208 down between Dhuri and Ludhiana.

205 up and 206 down Sentinel Coaches between Dasuya and Jullundur City

For timings at intermediate stations, reference should be made to Station Masters concerned.

CHIEF OPERATING SUPERINTENDENT.

Facsimile of poster and advertisement used by the North Western Railway of India to draw attention to the new railcar services

Railcar Services in North Western India

THE eleven diesel-mechanical railcars received by the North Western Railway of India during the last part of 1938 and the early weeks of 1939 began to go into service round Jullundur in February, but since the middle of May have been providing numerous services on a variety of broad-gauge lines in the vicinity of Jullundur City, Amritsar, and Ferozepore, as detailed in the timetable reproduced in the adjacent column, which is a facsimile of the North Western Railway's advertisement published in several Indian papers.

Passenger Accommodation

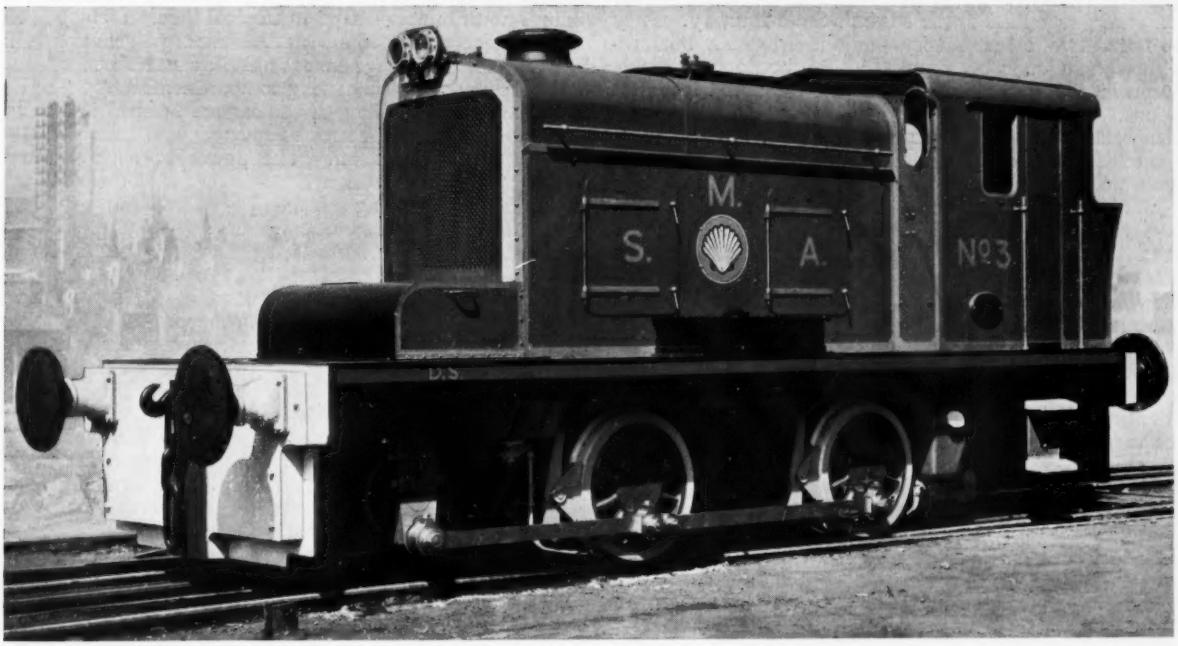
In view of the number of cars and the intense service which it was proposed to operate with them, considerable attention has been paid to the training of the drivers, under the guidance of the Ganz engineer who accompanied the railcars from Budapest to India. The car interiors are laid out solely for third class passengers, and there are 101 seats on a tare weight of 31 tons and within a car body length of 68 ft. The new services represent accelerations over the previous timings, which were maintained by steam trains and Sentinel steam railcars, and are intended to cope with the intense and still growing competition from road transport organisations. Only wooden seats are provided, but the windows are all of the drop type and are fitted with wooden sun louvres. The interior finish is of polished plywood, and down the white ceilings are numerous roof ventilators and electric lights. There is a lavatory near the centre of the car. These cars were illustrated and the mechanical portions and power plants described in the issue of this Supplement for February 17 last.

These railcars can maintain a top speed of 55 m.p.h. on straight level track, and can run at 37–38 m.p.h. up 1 in 100 grades. Fuel sufficient for a run of about 600 miles is carried, and the individual car mileages range up to 475 a day. A driving position is provided at each end of the vehicle to obviate turning.

One of the new 250-b.h.p. Ganz cars about to leave Lahore station

OIL-ENGINED SHUNTER WITH MODERN TRANSMISSION

Torque transmission during gear changes gives improved operation



5-ft. 6-in. gauge locomotive for heavy slow-speed yard service

A NEW 30-ton four-wheeled diesel-mechanical shunting locomotive for the Shell-Mex organisation has been completed recently by Hudswell, Clarke & Co. Ltd., and is equipped with numerous fittings designed to prevent the emission of sparks, even down to the covering of the buffer heads, and the provision of a 300-gal. water tank so that the rails may be watered should slipping occur and give rise to any sparks.

Power is provided by a Gardner 8L3 engine carried on the locomotive frame structure. This engine is set to give maximum outputs of 204 b.h.p. at 1,200 r.p.m. and 175 b.h.p. at 1,000 r.p.m., the respective torques being 890 and 915 lb.-ft., and the m.e.p.s 91 and 93½ lb. per sq. in. The maximum torque of 938 lb.-ft. and maximum m.e.p. of 96 lb. per sq. in. occur at a rotational speed of 650 r.p.m. The eight cylinders have a bore and stroke of 5½ in. by 7¾ in. and the piston speed at maximum revs is 1,545 ft. per min. The engine incorporates all the usual Gardner L3 features including direct injection, crankcase in two parts with the lower portion carrying the bearings, iron cylinder blocks cast in pairs, aluminium alloy pistons, C.A.V.-Bosch fuel injection pumps, and Gardner nozzles.

Transmission

The transmission comprises a Traction-type gearbox with Tele-change preselective gear, both evolved by the Hydraulic Coupling & Engineering Co. Ltd., and applied previously by Hudswell-Clarke to a number of diesel locomotives. It is designed to give track speeds of 3, 5 and 9 m.p.h. with top engine revs. A Vulcan-Sinclair hydraulic coupling is incorporated in the transmission.

Only a slight loss of torque during gear-changing is a feature of this transmission. The gearbox has constant-mesh gears and dog clutches with baulking rings to prevent engagement except on synchronism, and by the use of an auxiliary friction clutch in parallel with the top-gear dog clutch, the tractive effort is maintained during gear-changing intervals when changing up; this auxiliary clutch is used only momentarily during the gear change, and is not used when changing down. The Tele-change operating mechanism provides finger-and-thumb preselective control, the actual changes being effected by interconnection with the clutch mechanism, to which is pivoted a rotating disc carrying a pawl. When the disc is rotated in one direction the pawl engages with a ratchet plate pivoted about the same centre as the disc. The ratchet plate turns when engaged by the pawl, and a lever extending from it causes the gearbox selector rod to slide, and so disengage one step and engage another. The disc is then turned backwards a little, so that the pawl is disengaged from the notch. In principle, another disc with separate rotating mechanism is added to the assembly, and a pin projecting from the pawl rests on the edge of this second disc, so that the pawl is held up clear of the ratchet plate. A notch is cut in the edge of the second disc so that the pawl pin can move into it and permit the pawl to engage with the ratchet, and thus move the gearbox selector rod, at the will of the driver.

HUNGARIAN EXPRESS RAILCAR.—A further 240/275 b.h.p. Arpad double-bogie diesel-mechanical fast railcar for speeds up to 75 m.p.h. has been ordered by the Hungarian State Railways from Ganz & Co., of Budapest, in order to supplement the present fast services from Budapest to Vienna, and to such Hungarian towns as Miskolc, Csap, and Pucs.

XUM

AIR-CONDITIONED CARS FOR INDIA

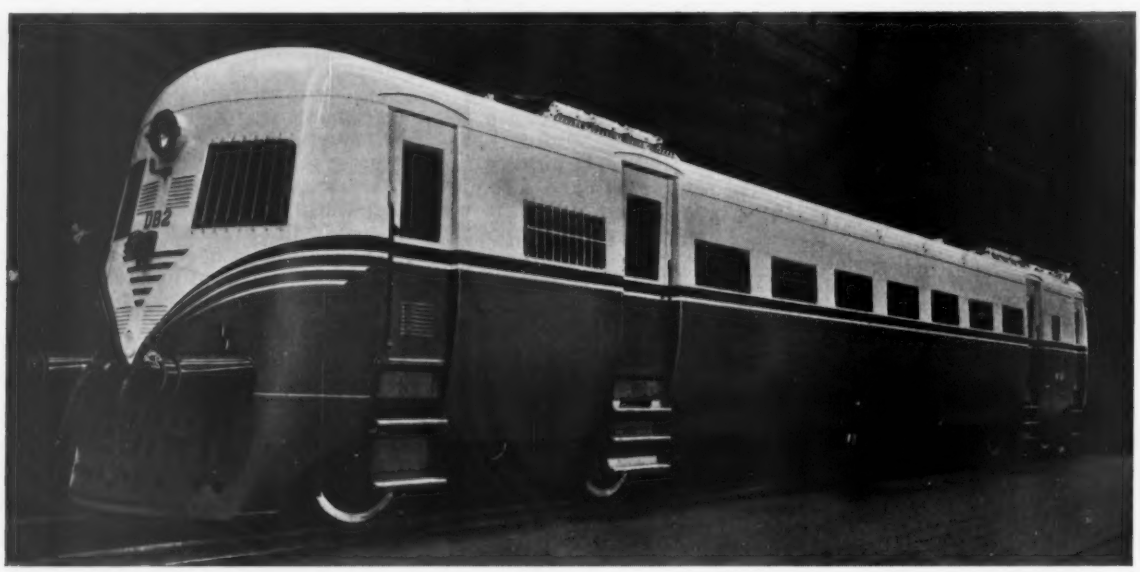
FOUR Drewry diesel-mechanical railcars have just been completed at the English Electric works at Preston, for operating improved passenger services on the 5-ft. 6-in. gauge lines of the Nizam's State Railway. They are not only the first railcars built in England, but also the first in India, to be completely air-conditioned and this equipment is applied both to the second and third class saloons.

On each of the two bogies is mounted a Gardner 6LW engine with a normal sea-level output of 102 b.h.p. at 1,700 r.p.m., but which, in view of the high altitude at which it will work, has been set to develop 87 b.h.p. at the same rotational speed under site conditions. Also mounted on the bogie is a Vulcan-Sinclair fluid coupling, a Wilson-Drewry four-speed epicyclic gearbox, and an axle-mounted spiral bevel reverse gear and single helical spur reduction gear enabling four speeds to be obtained in either direction of travel. Driven by the engine is a 24-volt Stone's Tonum lighting dynamo, which charges its own battery system, comprising a 19-cell Alconum cadmium-nickel battery with a capacity of 117 amp. hr. The two batteries of the car were supplied by Stone and are connected in series to supply 48-volt current for the air-conditioning evaporator fans. Multiple-unit operation is envisaged, and this is made possible by a patent system of electro-pneumatic remote control which gives positive and synchronised speed changes from any given remote control position. The admission of air to the cylinders mounted on the transmission units is controlled by a series of electro-pneumatic valves. The air supply for the controls is taken from the Westinghouse brake system.

Mechanical Portion

The cars measure 66 ft. in length over headstocks and have bogies pitched at 47 ft. 2 in. centres. The underframe and body frame form an integral all-welded steel structure, to which the side and roof panelling is spot-welded. Seating is provided for 84 passengers, of whom 14 are carried in two purdah compartments. Second and third class lavatory accommodation is provided, and the water is raised by means of compressed air taken from the braking system. The passenger seats are arranged in pairs, back to back; they are provided with Dunlopillo fillings and are upholstered in tropical hide. Light parcels racks extend down the sides of the main passenger saloon and additional baggage space is also available beneath the seats and in one of the driving compartments. The interior panelling and the ceiling of the car are finished in Rexine and the dovetail steel floor is covered with cork overlaid with battleship linoleum. The power bogies are interchangeable, and provision is made on all of them for the mounting and driving of the air-conditioning generator should substitution become necessary. The axles are supported in Timken roller bearings and the wheels are of the forged steel type with separate tyres.

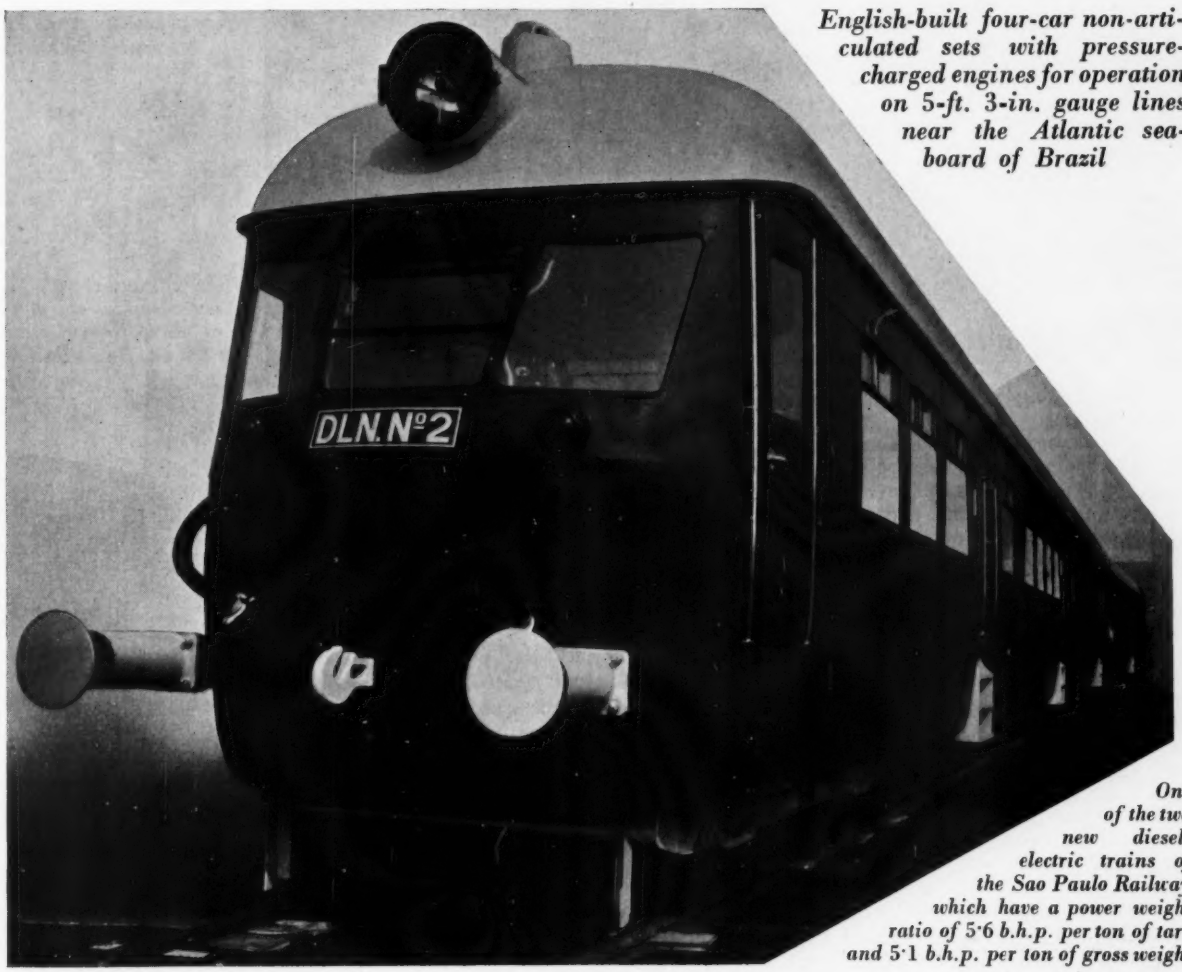
Constantly circulating dust-free air at the correct temperature and humidity for passenger comfort is supplied by Stone's air-conditioning system. Fresh air is mixed with a proportion of re-circulated air and is delivered from the evaporator unit through downwardly discharging ducts or grilles in the ceiling of the coach. The air temperature is controlled by a series of thermostats. The equipment includes a 10-kW 50-volt generator mounted on one of the two power bogies and this supplies current to a compressor motor and for the fan motor of the condenser unit. The compressor and condenser units are mounted below the underframe. Freon is used as the refrigerant. The system is controlled by a panel in one of the driving positions, and when the switches are on and the desired temperature selected, the equipment is entirely automatic in its operation, and pilot lights are provided to show when the necessary refrigeration has taken place. As the air-conditioning system delivers a constant supply of fresh and cool air to the saloons, all the windows except six are of the fixed type. The six half-drop lights can be opened in case of emergency. All glazing is carried out in Calorex glass and particular attention has been paid to the insulation of the body, which is achieved by means of Tropal mattresses enclosed in Alfol sheeting and attached to the Sundeala or Limpet interior panels.



175-b.h.p. double-engined Drewry diesel mechanical railcar, Nizam's State Railway

LUXURY DIESEL TRAINS FOR SOUTH AMERICA

English-built four-car non-articulated sets with pressure-charged engines for operation on 5-ft. 3-in. gauge lines near the Atlantic seaboard of Brazil



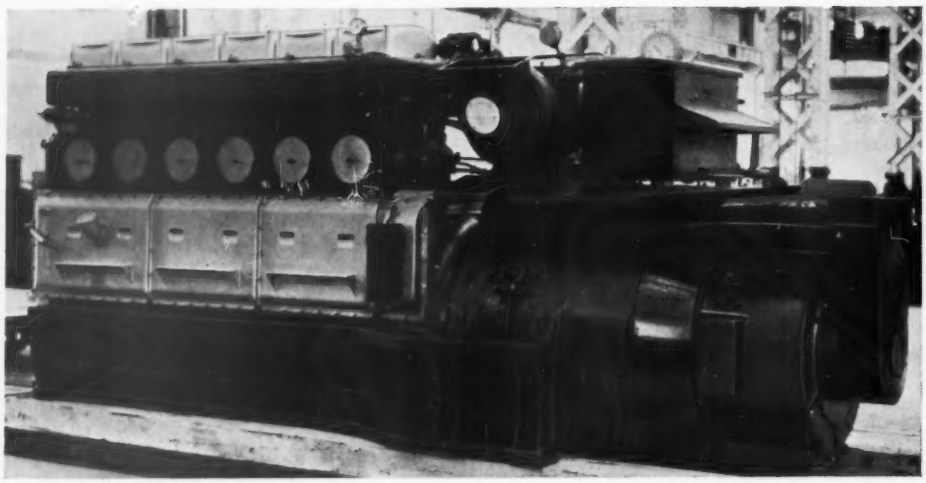
One of the two new diesel-electric trains of the Sao Paulo Railway which have a power weight ratio of 5·6 b.h.p. per ton of tare and 5·1 b.h.p. per ton of gross weight

FOLLOWING the successful operation of *Cometa*, the three-car diesel electric *de luxe* train supplied by Armstrong-Whitworth in 1934, the Sao Paulo Railway ordered two further trains of greater power and capacity from the same builders, and these have just been shipped to South America. They are composed of one power and three passenger cars in non-articulated formation seating 134 passengers, and power is provided by a pressure-charged engine with an output 33 per cent. greater than the engine installed in *Cometa*. The contract for the trains was carried through under the direction of the railway company's consulting engineers, Messrs. Fox and Mayo, the power vehicle and equipment being supplied by Armstrong-Whitworth & Co. (Engineers) Ltd., and the carriage portion by the Birmingham Railway Carriage & Wagon Co. Ltd.

One of the new trains has been named *Estrella* and is painted dark blue with a cream roof; the second train is named *Planeta* and is painted red with a cream roof. Both sets are to be used, as is *Cometa*, for first class passenger traffic between the port of Santos and the city of Sao Paulo, and on the celebrated Sierra incline will be raised and lowered by cable. It is the equipment on this section which caused the train to be limited to about 194 ft. in length and to about 108 tons in weight without passengers and luggage. The distance between Santos and Sao Paulo is 49 miles, and the summit of the line is 2,600 ft. above sea level. The maximum designed speed is 60 m.p.h. and the train has to negotiate six-chain curves.

Power Equipment

At one end of the train is a double-bogie steel power vehicle housing all of the power equipment and all of the transmission equipment except one traction motor, which is on the car at the other end of the train. The power car weighs 47½ tons, of which the bogies account for 10¼ tons, and is coupled in normal fashion to the adjacent passenger vehicle, but has an outer full-width vestibule sheathing in order to preserve an unbroken appearance of the exterior. In addition to the power plant, this vehicle also houses a buffet and the guard's locker. There is one driving compartment in the power car and another at the opposite end of the train. The roof of the power car is removable so that the main engine-generator unit can be lifted or lowered *en bloc* during an overhaul.



Left: 600-b.h.p. Armstrong-Sulzer engine pressure charged on the Büchi system, and with English Electric main and auxiliary generators carried on the same bedplate

Below: Interior of first class saloon in one of the new diesel-electric trains for the Sao Paulo Railway

Standard buffing and drawgear is fitted for use on the Sierra incline.

Power is provided by a four-stroke Armstrong-Sulzer 6LDA25 engine pressure-charged on the Büchi exhaust-gas turbo system. The six cylinders have a bore of 250 mm. and a stroke of 350 mm., and are set to give a maximum output of 600 b.h.p. at 750 r.p.m., under which conditions the m.e.p. is 100 lb. per sq. in. and the piston speed 1,720 ft. per min. The control system allows the engine to run also at speeds of 620 and 450 r.p.m. with corresponding maximum outputs of 462 and 203 b.h.p.

The crankcase of the engine is fabricated of steel throughout and is combined with the sump; moreover, the side frame is extended at one end to carry the main generator, and is supported on the car frame through the intermediary of rubber pads. Aluminium side inspection doors and end covers give access to the main bearings, big ends and timing gears. The cylinder block is of cast iron and is bolted to the crankcase; it carries renewable cast iron cylinder liners. Separate iron castings are used for the cylinder heads and each carries one inlet valve, one exhaust valve and the fuel injector. The crankshaft is of oil-treated carbon steel with hollow-bored crankpins and journals, and is carried on seven bearings composed of steel shells lined with whitemetal, whereas the big-end bearings of the nickel-chrome steel connecting rods have gunmetal shells lined with white metal. The gudgeon pin bearing is of the stepped type with a phosphor-bronze bush; it is of nickel steel and is supported in a piston of aluminium alloy which carries four compression and two scraper rings. The camshaft is located in a casing bolted to the lower part of the cylinder block; it runs in phosphor-bronze bearings and is driven by gears from the camshaft. The governor is driven by bevel gears and a chain drive to the water pump is taken from one of the intermediate timing wheels. Fuel is injected by C.A.V.-Bosch pump elements through C.A.V.-Bosch nozzles. An Auto-Klean strainer is inserted in the fuel circuit, and Zwicky filters at the fillers. Pressure lubrication is used for all parts except the cylinder walls, and a Stream-Line oil renovator containing two electric heating elements is included in the lubricating oil circuit.

The Büchi pressure-charger is attached to a seating above the main generator. Air is drawn to it through a perforated plate attached to the vehicle side above the cant rail, and then through two Vokes air filter panels. Flexible bellows connect the filters and the blower, and the air ducts are lined with Mascolite to minimise noise. There are two independent exhaust manifolds, each connected to three cylinders and leading to the inlet of the exhaust-gas turbine of the pressure-charging set. The turbo blower is water cooled through a bypass from the engine cooling system, which incidentally includes roof radiators and is under thermostatic control. The chain-driven centrifugal water pump has a capacity of 9,000 gal. an hour.

The engine governing gear is operated through a series of oil-electric valves controlling the oil supply to the stop-and-start cylinder, injection timing cylinder, governor, and rheostat oil motor used in conjunction with the automatic power control gear to maintain constant horse-power corresponding to each speed. The automatic control gear is also under the influence of the engine induction air pressure in order to provide a control which is responsive to changes in induction pressure as well as to changes in speed. The oil supply for the control is taken from the cooling pump in the lubricating oil circuit at a pressure of 50 lb. per sq. in. Any alteration of the load on the engine tends to decrease or increase the speed, and the governor alters the quantity of fuel injected to suit the new load. The quantity of fuel injected at each power stroke is determined by the fuel pump control rod which is connected to the governor shaft. This shaft has a separate hand-controlled cut-out lever for each pump element, so that any cylinder can be cut out of action. The amount of fuel injected, and thus the engine torque,

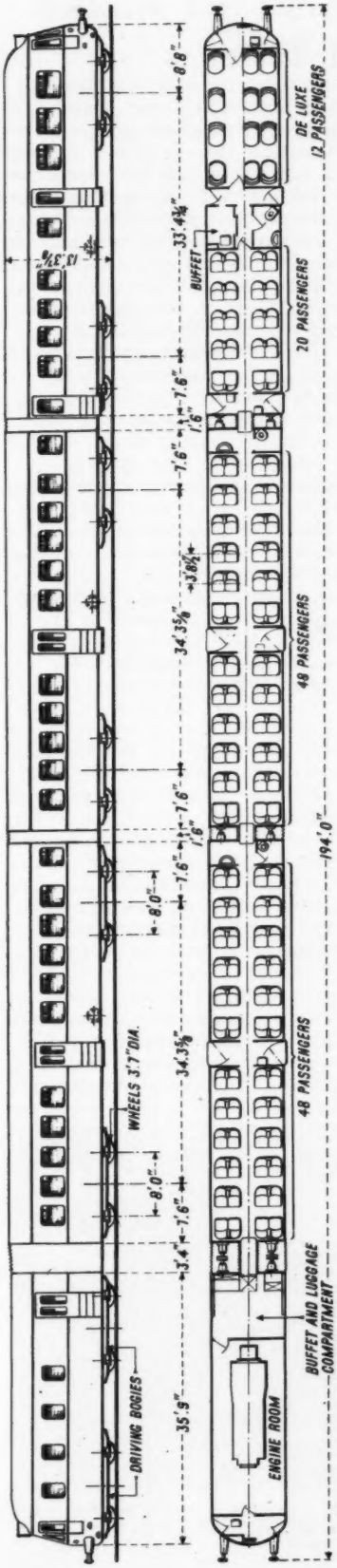


Diagram of the 600-b.h.p. four-car train for first class traffic on the Sao Paulo Railway; the weight with a full complement of passengers is 117 tons. The three passenger cars are close coupled, and each has a brake handwheel inside the skirting for use when descending the Sierra

is regulated automatically through an oil motor having a radial piston which is attached to the regulating arm of a rheostat inserted in the self-excited field of the main generator, and by which the power output of the generator is varied. It is impossible to increase the engine load above that set by the normal torque corresponding to any controller position. The fuel pump control rods have definite positions corresponding to the controller positions, so that a definite quantity of fuel is fed into the cylinder at each power stroke; if for any reason one cylinder is working at a decreased output the engine speed will tend to fall, and the rheostat control will operate to reduce the generator output accordingly, thus preventing overloading of the remaining cylinders.

Transmission and Electrical Equipment

The electrical equipment was furnished by the English Electric Co. Ltd., and comprises principally a direct-coupled six-pole main generator with interpoles; an overhung auxiliary generator; and three high-speed motors, two mounted on the underframe of the power car and one on the underframe of the passenger coach at the opposite end, and each driving a single axle through a cardan shaft and worm reduction gear. The main generator has a maximum voltage of 750 at zero current and a maximum current of 1,500 amp. at 225 volts. The one-hour rating at 750 r.p.m. is 850 amp. 430 volts, and the continuous rating at the same speed 750 amp. 525 volts. Each motor weighs 3,130 lb. and has a one-hour rating of 275 amp. 475 volts, the temperature rise by resistance in the windings being 120° C., and measured by thermometer at the commutator, 90° C. The armature is carried on S.K.F. roller bearings. In order to guard against any racing if a defect should occur in the mechanical part of the transmission, the motors have an overspeed mechanism which comes into operation at a speed of 2,200 r.p.m., that is, 25 per cent. above the normal top speed. Two 54-cell 197-amp.hr. Chloride lead acid batteries are included in the electrical equipment; one of them provides the current for engine starting and for the control circuits, and the other is for the power car and train lighting. Normally the battery duties will be changed over every day. The headlamp is of Stone's Tonum type of 250 watts capacity at 110 volts; the train lights are 110 volts 40 watts gas-filled lamps. Other electrically-driven auxiliaries include ventilating fans, and windscreen wipers.

Carriage Portion

Both the car underframes and bogies are welded up of high-elasticity steel. The main solebars are built up from angles but the side sills are of Z section. The suspension system comprises individual laminated springs and rubber auxiliaries above the Timken roller bearing axle-boxes, and bogie bolsters supported on helical springs and fitted with Luvax shock absorbers. The disc wheels have been asbestos sprayed.

As the power car was to account for about 47 tons of the total desired weight of 108 tons without pay load, it was necessary to use aluminium for the coach panels and roofs in order to keep the weight of the three large-contour passenger vehicles within the limits. The body framing is of light but deep steel flanged channel sections, and the pillars, carlines and floor bearers are arranged almost as continuous hoops. The floors are formed of galvanised steel sheets covered with treated cork and overlaid with linoleum. Insulation against heat and noise is obtained by spraying Roberts's asbestos to the inside of the aluminium panelling and interior lining, and the underside of the dove-tail flooring is sprayed with asbestos finished with hard surface cement.

The decoration of the saloons has been carried out in polished mahogany up to the cantrail level, and above that in cream enamel. Ventilation is by Airstream ventilators above the windows and Monarch extractors in the roof. The seats supplied by G. D. Peters Limited are upholstered in rattan and buff-coloured hide. Each saloon has two electric fans, and these, with the lighting and buffet equipment are of Stone's manufacture. In addition to the buffet-kitchen carried in the power car, and used for the passengers in the adjacent coach, there is another set of buffet-service equipment near the other end of the train for the passengers in cars Nos. 2 and 3. Part of No. 3 car is being fitted out in Brazil as a Pullman saloon. The lavatories and toilet rooms in each car are finished in white enamel and have chromium-plated metallic fittings. In each driving position is a vacuum brake handle, hand brake, controller with deadman attachments, reversing handle, speedometer, and a control desk carrying the usual gauges and meters.

The Heating of Railcars and Diesel Trains

IN the course of the discussion on Mr. H. J. Fountain's paper on the utilisation of waste heat from diesel engines, read before the Diesel Engine Users Association on March 8 and abstracted in the issue of this Supplement for April 14, Mr. T. Hornbuckle (L.M.S.R.) said that one of the things which had to be borne in mind when designing the heating system of the L.M.S.R. three-car diesel train was that it had to fit in with the ordinary train heating system. It was not practicable to put passengers into a train on a cold morning and wait for the engine to start running in order to warm up the carriages. There was in existence a pre-heating system with steam boilers for the purpose of pre-heating trains, and the diesel train had to be able to utilise this standard pre-heating system. Then it seemed desirable to use the standard steam radiators, and the steam-heating system of the diesel therefore was built up around the existing units. There were six engines on the train but only two boilers applied to four engines, so that two-thirds of the heat available was being employed for heating the train and that amount of heat was more than adequate for maintaining the temperature. The running of diesel engines successfully involved not only maintaining the mechanical parts but consisted also in obtaining the maximum value from the fuel, and in that respect the efficient cooling of the engine could not be ignored; nor could the utilisation of the maximum possible amount of heat from the exhaust gases.

Direct Exhaust Heating

Mr. H. D. Bush said that the problem of diesel-train heating was examined long before the thimble-tube type boiler was introduced and the first line of development was the method of direct heating of the air by some form of heat exchanger, to transmit the heat from the exhaust gases to the air. After carrying out extensive tests, the direct heating method was abandoned because, even at comparatively low exhaust gas temperatures, the hot steel structure gave off a metallic odour which was very objectionable. The next stage was to turn to some form of heat converter in the form of a boiler, and the introduction of the thimble-tube type boiler solved many of the problems, particularly in foreign countries. One type of boiler had the advantage of being worked dry, so that if the water system failed there was no consequent material damage. The first unit of this type for use with diesel rail traction was tested out with a 1,330 b.h.p. engine, two of which were installed in the Canadian National Railways twin-unit diesel-electric locomotive. The tests indicated that generally the capacity of the boiler in terms of the b.h.p. generated by the diesel engine was such that the boiler was capable of generating 1 lb. of steam per h.p. hr. at 100 lb. per sq. in. pressure, which at the normal load of the particular engine was 1,250 lb.

Heating during Coasting

Another problem with diesel traction was in connection with a diesel-electric train which travelled over a mountainous route rising, say, 2,500 ft. in 35 miles, with full engine output, and then descended a grade of 35 miles, or an hour's run without engine power—the return journey obviously being similar. With the engine power shut off, there was no heat for the coaches, and this difficulty was overcome by providing electric immersion heaters in the boiler. The transmission was electric, and automatically as the driver opened the electric power circuit he closed the electric immersion heater circuit and put the heaters in circuit with the generator and so maintained the heat output whenever the engine was running at the idling speed. This system obviated the necessity of an oil-fired boiler. The heating of the train prior to its going into service sometimes determined whether hot water or steam was to be used. When a train had been standing all night, with hot water there was a reasonable water temperature above atmosphere in the boiler early in the morning, and a few minutes after starting up the engine there was a small amount of heat to warm the train, whereas with steam it might require an hour or more to provide the necessary heat. In one particular equipment, it took only 12 to 16 min. from the time the train left the running sheds to generate heat for the passenger compartments.

RAILCAR MILEAGES.—The three Maybach-engined 175-b.h.p. diesel-mechanical railcars at work in slow stopping services on the Belgian National Railways have now covered an average of over 465,000 miles each.; 36 Renault 250-b.h.p. double-bogie railcars placed in service in France throughout the course of 1934, have now run an average of about 300,000 miles each ; and 10 Renault 265-b.h.p. cars introduced in France in 1936 have averaged about 240,000 miles.

BRAZILIAN DIESEL SERVICE.—Although the five Fiat twin car 290-b.h.p. diesel-mechanical trains for the Central Railway of Brazil were delivered over a year ago, they did not go into regular operation until June 1 last, owing to extensive trials and negotiations on technical matters connected with the design and performance of the sets. The services they now operate leave Rio de Janeiro (Alfredo Maia station) for Sao Paulo and Bello Horizonte on Tuesdays, Thursdays and Saturdays, returning on Mondays, Wednesdays and Fridays. The Sao Paulo train leaves Rio at 8.40 and arrives at its destination at 17.00, after making six intermediate stops. The Bello Horizonte train leaves at 7.50 and also makes six intermediate stops before reaching its destinations at 18.40, a saving of 4 hr. on the previous steam time, compared with a saving of 2 hr. on the Sao Paulo route. The fare is the same as for ordinary express trains, but there is a seat reservation fee.

HIGH-POWER RAILCARS IN FRANCE.—The six single engined 500-b.h.p. Renault A.D.P. railcars delivered to the Région de l'Ouest of the S.N.C.F. are now shedded at Caen, and are working trailer-hauling services between that town, Rouen and Le Mans. Ten similar cars for the Région du Sud-Ouest have been centred on Aurillac and are operating over the heavily-graded lines in that area, including services to Bordeaux. The latest type of powerful railcar in France is the Renault ADX² model, with two 300-b.h.p. engines, as described in the issue of this Supplement for May 12 last, but a further series of 600-b.h.p. Decauville cars is being built for operation in the Savoy area of the Région du Sud-Est. The Decauville cars, with two Saurer 300-b.h.p. engines, are to have electric transmission, whereas the other types mentioned above have four-speed mechanical transmission. All these cars haul trailers if required, or can be operated in multiple-unit.

Railcars for Light Provincial Traffic

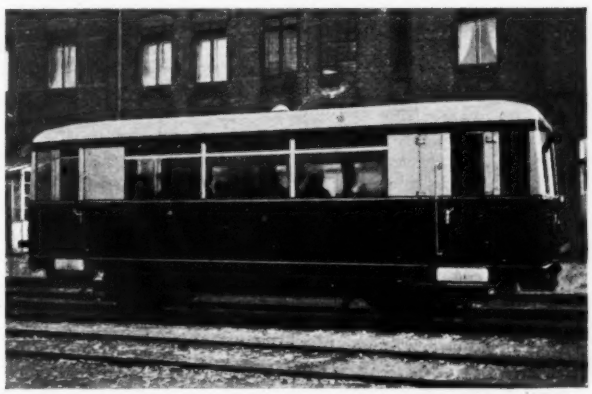
AMONG the small private lines in Germany is the standard-gauge Prenzlau District Railway, operating a radial system totalling 78 miles and centred on the town of Prenzlau, near Stettin. There are five different routes running out of Prenzlau, each with five to ten services a day and operated by over a dozen steam locomotives, half-a-dozen diesel railcars, about 30 coaching vehicles and 300 freight wagons. Owing to intense road competition the old steam-hauled mixed trains were given up some years ago, and light diesel railcars were introduced on accelerated schedules.

The four-wheel Wumag railcars have 37 seats and a nominal standing capacity of 17, but over 60 passengers are carried in rush hours. Nevertheless, the cars are operated by one man and only in periods of peak traffic is the driver relieved of the duty of issuing tickets, shutting the doors, and announcing the next stop. The majority of the stations have no staff, and as there are few signals, the driver also has to get into telephonic communication with Prenzlau at one or two points. The car body and frame is of all-welded steel and has a length of 28 ft. 7½ in. and a width of 8 ft. 1½ in. The 2 ft. 11½ in. wheels are spread over a base of 14 ft. 9 in. and the axles are carried in Peyinghaus boxes.

Interior Arrangement

Back-to-back seats with welded tubular steel frames are used, and are arranged three on one side and one on the other of the central gangway, and three seats are provided alongside the driving position at each end of the car. All seats are well sprung and are upholstered in green plush. Three folding seats are also arranged in the platform at one end, which is used for carrying bicycles and parcels; entrance is by a 3 ft. door on to this platform and a 2 ft. swing door at the other end. There are no partitions between the entrance platforms and the passenger saloon. The interior decoration is in oak, with a white roof and a floor covered in linoleum. Ventilation is by inside-hinged openings above the windows, drop lights in the doors, and a ventilator in the roof. Heating of the car is effected by the engine circulating water, supplemented in cold weather by hot water from a coke-fired stove, and this system can also heat the engine cooling water before starting up in winter.

Magirus oil engines developing a maximum of 65 b.h.p. at 2,000 r.p.m. in six 88 mm. by 125 mm. cylinders are used in some of the cars, and together with the radiator and four-speed Mylius gearbox are carried on a subframe below the car floor. The cylinder heads project through the floor below one bank of seats. With maximum engine revolutions the track speeds on the four gear steps are approximately 8, 15½, 26, and 46½ m.p.h., but in normal service the top speed is fixed at 37 m.p.h. (60 km.p.h.). Attached to the engine are a 500-watt dynamo and a 2·5-h.p. 24-volt starting motor. A 20-gal. fuel tank is housed beneath the three passenger seats against the driving position at one end, and under the corresponding seats at the other end is an instrument and apparatus box. Another larger car has the double-bogie layout and is equipped with two 125-b.h.p. Deutz engines and Mylius mechanical transmission.



65-b.h.p. 8-ton (tare) railcar of the Prenzlau District Railway

The four-wheel cars weigh about 18,000 lb. with supplies but without passengers, and the provision of 8 b.h.p. per ton of tare or 5·4 b.h.p. per ton of gross weight is sufficient to enable the cars to maintain schedule speeds of 23·5 m.p.h. compared with the 15 m.p.h. of the preceding steam trains. Although the five lines have numerous curves down to 800 ft. radius and grades as steep as 1 in 50, the fuel consumption does not exceed 18 litres per 100 km. (6½ gal. per 100 miles). With a normal load of passengers the four-wheel cars can reach a speed of 25 m.p.h. in 33 sec. on the straight level. The same car design is used on numerous German private lines of short length, and over 50 of the type are at work.

French 4,400-B.H.P. Locomotives

Latest particulars show that since being put into regular service at the beginning of November, 1937, until withdrawn for some special tests at the end of February last, the Sulzer-engined 4,400-b.h.p. diesel locomotive 262.BD.1, built for the ex-P.L.M. Railway had covered over 150,000 km. The second locomotive, 262.AD.1, with M.A.N.-type engines, was put into service in March, 1938, and to the end of March this year had covered 108,000 km. In the haulage of express passenger trains the fuel consumption of both locomotives averages 0·64 kg. per 100 tonne-km. trailing, but with express trains making frequent stops and with really high-speed trains the consumption rises to 0·875 kg. per 100 tonne-km. trailing. On certain trials between Paris and Laroche the consumption of locomotive 262.AD.1 was 0·585 kg. per 100 tonne-km. trailing; of locomotive 262.BD.1, 0·625 kg.; and of one of the standard coal-burning 231.G class Pacifics, 2·02 kg. Some slight trouble has been experienced in locomotive 262.AD.1 by heating of the big ends, and on one of the four main engines serious damage was caused by the breakage of a big-end bolt, which resulted in the locomotive being out of service from June 29 to October 27, 1938. On locomotive 262.BD.1 the blades of the Rateau turbo-charger were broken and a new type of blade was substituted, the locomotive meanwhile operating without pressure-charging in some of the cylinders.

With a trailing load of 535 tons either of these two locomotives can accelerate from rest up a curved 1 in 125 grade to 12½ m.p.h. in 37 sec., to 25 m.p.h. in 90-92 sec., to 37 m.p.h. in 160 sec., and to 50 m.p.h. in 270 sec. within a distance of about 3·5 km. A top speed of 60 m.p.h. can be attained on this grade, and is reached in about 7½ min. from the start. The d.b.h.p. from approximately 40 m.p.h. upwards is maintained about constant at 2,350, but d.b.h.p. figures in excess of 3,000 are recorded at fast speeds when the oil engines are working at full load. A d.b.h.p. of 1,950-2,000 suffices to keep a 450-ton train moving at 60 m.p.h. up a 1 in 125 gradient.

XUM

NOTES AND NEWS

Producer-Gas Railcars.—Eight small 150-b.h.p. De Dion Bouton 45-seater railcars are being introduced on the standard-gauge lines round Mont de Marsan and Luxey belonging to the Departmental Railways of Landes, and will also run to Bordeaux. They have a top speed of 50 m.p.h. and run on 50-lb. rails.

New Type of Oil-Filter.—A new pattern of Stream-Line filter has been evolved by Stream-Line Filters Limited, of London, S.W.8, and can be installed in road vehicles or in railcars of small capacity. The new MC.7 model operates on the usual Stream-Line edge-filtration principle, but requires no routine replacements—only the draining of the sludge every few thousand miles. In certain installations the original oil has been found in excellent condition after a vehicle mileage of over 30,000.

Rhodesian Railcar.—During the first two years of its service on the Salisbury-Shamva branch, the 240-b.h.p. Ganz car of the Rhodesian Railways covered 97,500 miles, with an availability of 90 per cent. No spare power bogie nor engine were available during this time. The gross receipts of the traffic handled by the car during these two years amounted to £11,441, and the operating costs totalled £5,554, leaving £5,887 to cover interest and depreciation charges and profit.

New Zealand Railcar Success.—Winter conditions now prevailing in New Zealand have not lessened the success of the new double-engined diesel-hydraulic Leyland-engined railcars put into service on the New Plymouth-Wellington line in April. Public response has been remarkably good, even from small towns such as Aramoho, the inhabitants of which have already bought nearly 1,000 tickets. The cars are of the series of six built last year, and described and illustrated in the issue of this Supplement for September 2, 1938.

Maybach Engine Orders.—The Maybach Motorenbau A.G. now has under construction at Friedrichshafen no fewer than 165 twelve-cylinder 650-b.h.p. engines pressure-charged on the Büchi system for installation in railcars and high-speed trains in Germany, Holland, and Norway, in addition to other non-pressure-charged engines of 410/450 and 225/250 b.h.p. for railcars. The number of Maybach engines now in rail traction service or under construction totals 810, with an aggregate output of 340,000 b.h.p. Railcars and trains equipped with Maybach engines have run approximately 80,000,000 miles.

American News.—The Great Northern Railroad has ordered 14 diesel-electric shunting locomotives of 1,000 b.h.p. from the Electro-Motive Corporation, the Chicago, Burlington & Quincy Railroad five 600-b.h.p. locomotives, and the Pere Marquette one 600-b.h.p. locomotive from the same maker. The high-speed diesel trains ordered by the Chicago & North Western to replace steam traction on the celebrated 400 express are expected to go into service in August. The locomotives are already in operation with the existing stock. The Silver Meteor diesel-hauled service between New York and Florida has proved so popular that additional facilities have been introduced to give a service to both east and west coasts of Florida every trip, instead of serving the two coasts with alternate trips as previously. During the month of May orders were placed for a total of 51 diesel-electric locomotives by American railways and industrial firms; no new steam locomotives were ordered during the month. The Florida East Coast Railroad is proposing to purchase two seven-car streamlined trains to be hauled by diesel locomotives. Two 2,000-b.h.p. Electro-Motive diesel locomotives have been ordered by the Kansas City Southern Railroad, and the Boston & Maine is enquiring for six 600-b.h.p. oil-electric switchers. The Burlington's newest Zephyr, *General Pershing*, has had its run extended from Kansas City to Lincoln, and at the moment is hauling a through sleeper running between St. Louis and San Francisco.

Publications Received

Swiss-Built Locomotives.—From the Swiss Locomotive & Machine Works, Winterthur, comes a 16-page booklet containing charcoal drawings of the various products of that firm, including diesel, electric, and steam locomotives and railcars, oil engines, change-speed gears, brake compressors, boilers, and the like.

Skoda Engines.—According to the April issue of the *Revue Skoda*, that firm is still building oil engines for the general market. Included in the high-speed list is a six-cylinder engine giving 400 b.h.p. at 1,000 r.p.m. and mounted on a welded steel underbed; a six-cylinder 100-b.h.p. engine running at the same speed; and a four-cylinder 40-b.h.p. engine running at 1,200 r.p.m. Loco-tractors of 20 and 28 b.h.p. are also illustrated.

Fuel Injection Equipment.—C.A.V.-Bosch Limited, of Acton, W.3, have produced a new instruction booklet on the service tools and testing apparatus for C.A.V.-Bosch fuel injection equipment. Illustrations are given of the various service and calibrating items required for a satisfactory set of bench apparatus, and notes on the arrangement of the shop and bench are included. The number of the brochure is MS-C10.

Timken Times.—British Timken publicity has taken some surprising twists within recent months, including the free distribution of copies of a leading American Sunday paper complete with 16-page comic section. A more staid and informative venture, suited to those whose desks do not bear the stains of chewing gum on their undersides, is the "Timken Times," a new quarterly review of Timken activities. The first number makes an excellent start, for it contains much that is of direct railway interest, as well as items, such as Mr. E. H. Doughty's exposition of the tapered roller bearing, which will be of value to a wide selection of engineers. "Timken Times" is produced under the direction of the man who of all British Timken's staff is best known in the railway world—Mr. J. E. Spear.

Drewry Railcars and Locomotives.—Although in the early part of its existence the Drewry Car Co. Ltd. was concerned almost exclusively with the supply of inspection trolleys, and later of light petrol-engined locomotives, a considerable increase in its activity has taken place during the last ten years with the boom in diesel traction. The standard Drewry four-wheel and six-wheel narrow-gauge locomotives of 75/100 b.h.p. have been supplied to several countries, but it is in the field of railcar applications that Drewry designs have reached their highest pitch, and such vehicles as the 100-odd cars shipped to Argentina, and the four air-conditioned cars for the Nizam's State Railway will bear comparison with any other small-powered railcars. All these designs, and other internal-combustion engined locomotives, railcars and power bogies are described in two brochures—Nos. 31539 and 2639—which have just been published.

Diesel Railway Traction

Railcar Concentration

IT is well known, though by no means always widely practised, that the best results from railcars are obtained if a number of the same type are kept at one depot, rather than shedding single cars here and there, or having a miscellaneous collection of vehicles at one centre. In an endeavour to improve to a greater degree the operation of its 700-odd railcars, the French National Railways organisation is engaged in developing this principle still further, although the " star " system has always been a characteristic of railcar working in France. All the Bugatti cars are now being concentrated either on the Région de l'Ouest (ex-Etat) which has the greatest number of Bugattis, or at the Strasbourg depot, which, incidentally, is close to the maker's works at Molsheim. All the De Dietrich cars are being transferred to the Région de l'Est or to the big railcar depot at Besançon, which, although on the ex-P.L.M. system, is not far from the old Ch. de fer de l'Est. The Région du Sud-Est is taking all the A.D.N. (Standard), Decauville, Berliet, and Somua cars, and in general these are being concentrated at Châlons-sur-Saône and Besançon, Grenoble, Roanne and Grenoble, and Avignon respectively. The Renault cars powered by one 500 b.h.p. 16-cylinder engine are being operated by the Régions de l'Ouest and du Sud-Ouest (ex-Etat and P.O.-Midi), and the Renault ABV (twin articulated 500 and 530 b.h.p.) and ABJ (single 265 or 300 b.h.p.) cars are being transfered to the new Lyons centre at Vaise. The Vennisieux railcar depot is to be closed. At the moment, 743 railcars are in operation, and are operated from 61 sheds.

Railcar Working in Indo-China

AN increase in the number of railcars, and the use of special trailers, is proposed by the Yunnan Railway and the Indo-Chinese State Railways, following some years of successful operation of Decauville, Renault, and Michelin vehicles. On the interurban Haiphong—Hanoi line of the Yunnan Railway, with a length of 63½ miles, the Decauville cars operate three accelerated services a day in each direction, taking 115 and 119 min. with three and five intermediate stops respectively, and two slower trips taking 135 to 145 min. with six to nine halts. The fast cars replace a steam train running to a time of 170 min. inclusive of four stops. The passenger-miles between the two towns has risen to 8,660,000 a year from 1,177,616 in the year 1934, and the receipts from $40,561 in 1934 to $137,613 in 1938. Exclusive of allowances for interest and depreciation, the railcars cost 2·034 French fr. per km. to operate, compared with 3·83 fr. per km. under the same conditions for steam. The initial cost of the Decauville cars was 711,000 fr. per car. Strong road competition has been quite eliminated by the use of these cars. On the 290-mile Yunnanfu—Ho-Keou route, with heavy grades and generally arduous working conditions, Michelin cars have been handling the sparse passenger traffic. The railcar service runs twice a week in each direction, and takes 12 hr. in the down direction inclusive of 20 stops (one lasting 51 min.), and 12 hr. 17 min. in the up direction, including 19 stops—one of 62 min. The railcars used have 15 *de luxe* seats in one car and 37 seats in the second car, as well as baggage and mail space. These cars have almost halved the overall time of the previous steam trains, and have increased the revenue from $22,065 in 1934 to $105,713 in 1938, and the passenger-miles from 574,390 to 1,382,703 in the same period. One of the Michelin cars cost 342,000 fr. to purchase, and the other 511,000 fr.; their operating cost on the Yunnanfu line is 2·33 fr. per km. exclusive of interest and depreciation charges.

The Scope and Use of Diesel Traction

THE use of railcars in Europe appears to have increased almost four-fold in the last five years, and there are more than 3,000 cars at work on the State and privately-owned lines on the Continent. Of this number, the Reichsbahn accounts for over 500, the Belgian National Railways for 40-odd, the French National Railways for nearly 750, Holland for 40 triple-car trains and a score of single-unit cars, Italy for 600 cars, Roumania for about 220, Hungary for about 220, and the Danish State Railways for 56 cars and railcar-trains. At the present time railcars work well over 40 per cent. of the passenger train-miles in Denmark, 22 per cent. in Italy, 22 per cent. in Hungary, 18 per cent. in France, and 11 per cent. in Holland. Advantage has been taken of the speed possibilities of railcars over long and short distances, although there is still plenty of scope for extension. Practically 75 per cent. of all the runs in Great Britain, Germany, France, and the United States booked at start-to-stop speeds of 70 m.p.h. or over are operated by diesel locomotives, railcars or railcar-trains, and if Britain is excepted the percentage is still higher, and at booked speeds exceeding 75 m.p.h. start-to-stop diesel traction is used exclusively. As indicated on pp. 102-104 of the July 7 issue of this Supplement, the operating costs of diesel railcars or railcar-trains are well below those of steam trains on a mileage basis, and often on a seat basis, too. The seat basis of comparison may not always be a sound one, as may be judged by observing the half-empty steam trains working in this and other countries. Interest and depreciation charges have always formed an appreciable proportion of the gross operating charges of diesel vehicles, but it seems now as if many of the allowances have been more than liberal. If steam locomotive methods of maintenance and renewal are followed there is no reason why the oil engine and transmission should not have a life of 40 or 50 years. With present methods and ideas there does not seem to be any reason why the most vulnerable parts of a railcar should not have a financial life equivalent to 20-25 years at an average of, say, 85,000 miles a year for ordinary main-line cars.

EXPRESS DIESEL LOCOMOTIVE OPERATION

An account of the experiences with the 600, 1,800, and 3,000 b.h.p. motive power units of the stainless steel Zephyr trains in the U.S.A.

INTERESTING information as to the behaviour of diesel stock on the Chicago, Burlington & Quincy Railroad, the first, and still one of the largest, users of high-speed trains in the U.S.A., was given by Mr. H. H. Urbach, Mechanical Assistant to the Executive Vice-President of the Burlington, in a paper presented to the Association of American Railroads in June.

The first diesel-electric motive power unit was that of the three-car Burlington Zephyr, introduced early in 1934. Since that time three further trains of 600 b.h.p. have been placed in service, and up to May 1, 1939, the four sets had made an aggregate mileage of 3,498,096. Towards the end of 1936 two 1,800 b.h.p. and two 3,000 b.h.p locomotive units were introduced, forming the power cars of the Twin Zephyr and Denver Zephyr trains; up to May 1 last, the two 1,800 b.h.p. units had aggregated 1,413,573 miles, and the two 3,000 b.h.p. sets 1,754,585 miles.

Layover Time

One of the 1,800 b.h.p. locomotives on the Twin Zephyr service has its layover at Minneapolis and is maintained at that point on a nine-hour layover, which is the total time between the arrival of the train at night and departure the next morning. One 1,800 b.h.p. locomotive is entirely maintained at Chicago on a 9 hr. 45 min. layover. The two 3,000 b.h.p. locomotives on the Denver Zephyr trains are maintained at both Chicago and Denver; the layover is approximately eight hours. The maintenance work on these two locomotives is divided between the Chicago and Denver terminals, and special facilities have been provided for the character of the work performed at each of these terminals. The on-time performance of these four locomotives on the runs as stated above has been 96 per cent. The availability of all the diesel road locomotives is 95 per cent. Recently a 1,000 b.h.p. two-stroke locomotive of an improved type has been installed. As it has been in service only a short time no comments can be made as to the maintenance requirements. Only certain parts above the crankshaft of this engine are interchangeable with the others in service.

Various Causes of Failure

The failures which have occurred and have been responsible for train delays are so varied in character that it is almost impossible to point a finger definitely at any one particular thing. The failures that have occurred were due to trouble with traction-motor bearings, connecting-rod bearings, pistons, cylinder liners, cylinder heads, and fuel injectors. As each 1,800 b.h.p. locomotive is equipped with two 900 b.h.p. diesel engines, where a failure occurs to a traction motor, connecting-rod bearing, piston or cracked cylinder head, comparatively little time is lost with the other 900 b.h.p. engine handling the train, as compared to stopping the train and getting a steam locomotive to handle. The same applies to the 3,000 b.h.p. units, as they are equipped with two 900 b.h.p. and one 1,200 b.h.p. diesel engines, and where a defective condition develops that makes it necessary to cut out one of the 900 b.h.p. units, comparatively little time is lost with the other two units in operation. If for some reason the 1,200 b.h.p. engine has to be cut out, it is then necessary to use a steam locomotive to handle the train.

Several road failures have occurred due to hot armature-shaft bearings and broken armature shafts. After each failure a thorough investigation was made but due to the damage that occurred, the evidence as to the cause of the failure had been entirely destroyed. In the case of burned-up armature-shaft bearings, investigations showed that these bearings were failing due to (1) over-lubrication; (2) roller bearings damaged in handling the traction motor; (3) bearings damaged because of too much lateral motion accumulating in the hanger bearings; (4) armature not properly balanced.

In making actual tests it was found that high temperatures could be set up in the armature bearings by forcing too much lubrication into the housings. As a result of the investigations instructions covering lubrication were changed from 15,000 miles to 30,000 miles; strict instructions were issued with reference to the careful handling of the traction motors in shipping them from the shops and during the time of application; the lateral motion in the support bearings was taken up and maintained at a closer tolerance; and in order to know that the armatures were properly balanced, an accurate dynetric balancing machine was installed in the shops where every armature is perfectly balanced at the regular inspection periods. [Some notes on the roller bearing failures were published in Mr. E. F. Weber's article in the issue of this Supplement for May 13, 1938.—ED.]

Parallel Wheel Treads

In addition, it was decided to use cylindrical treads on the power-truck wheels. Tests indicated that cylindrical treads steadied the riding of the locomotive and had a definite tendency to reduce the lateral thrusts of the traction motors at high speeds. It is believed that with the frail construction of the armature roller bearings (due to the limited space available), and with the very heavy end thrust of the traction motor on the hanger bearings (which on a two-degree curve at 100 m.p.h. amounts to 1,875 lb. per bearing), that the armature breaks out the end of the roller enclosure and causes the bearing to fail and heat. As a result of wear on traction motor pinions and on axle drive gears, specific wear limits have been set up which it is believed will also have a tendency to assist in eliminating armature-shaft-bearing failures. Several failures have occurred because of broken armature shafts. The magnaflux test is now used on the exposed ends of armature shafts each time a traction motor is sent to the shop for mileage inspection. Since putting these practices into effect, armature-axle failures and armature-shaft-bearing failures have been almost eliminated.

Through the careful inspections that have been maintained since these diesel locomotives went into service, it has been found that the traction motors on the 600-b.h.p. units will run 200,000 miles between inspection, and on the larger locomotives 150,000 miles. There are 34 traction motors in daily service and there is an assignment of 9 for protection and maintenance, this large number having been built up when motor failures were frequent. The inspection and repair work of these traction motors has been confined to the Aurora shops, where the dynetric balancing machines and other facilities have been pro-

vided to make all necessary repairs economically and expeditiously.

An undesirable situation exists when an armature-shaft bearing fails, as no means are provided to cut the traction motor out of service; the armature drops down on the pole pieces and practically destroys the armature, pole pieces, and field coils, and in some cases has caused the wheels to lock and slide. In several instances where this has occurred *en route* it has been necessary to set out the locomotive and handle the train with a steam locomotive. In some cases, when an acetylene torch was immediately available, the armature shaft has been cut off. Some means must be provided so that in case of an armature-shaft-bearing failure, the particular traction motor can be disengaged from the wheel and the locomotive continued to handle the train with the other traction motors.

Wheel Changes

When the diesel locomotives were first put into road service they were equipped with a 1½-in. thick rim wheel according to A.A.R. specification M-107-34. The analysis was: carbon, 0·67 to 0·82 per cent.; manganese, 0·60 to 0·85; phosphorus not over 0·05; sulphur not over 0·05; silicon not less than 0·15. The service obtained from these wheels was fairly successful and averaged approximately 104,000 miles during the life of the wheel. In the meantime research work was done by the steel companies and three wheels were developed, and were known as low-carbon molybdenum wheels, the analysis of which is as follows: carbon 0·48 to 0·63; manganese 0·60 to 0·75; phosphorus not over 0·04; sulphur not over 0·05; silicon 0·15 to 0·25; molybdenum 0·40 to 0·50.

When the 1,800 b.h.p. and the 3,000 b.h.p. diesel locomotives were built they were equipped with this specification of wheel, with a 2-in. thick rim. It was soon found that due to the severe braking the wheels were thermal checking badly and shelling out, and after running for a period of a year, it was realised that an average of only 84,000 miles was being obtained during the life of the wheel.

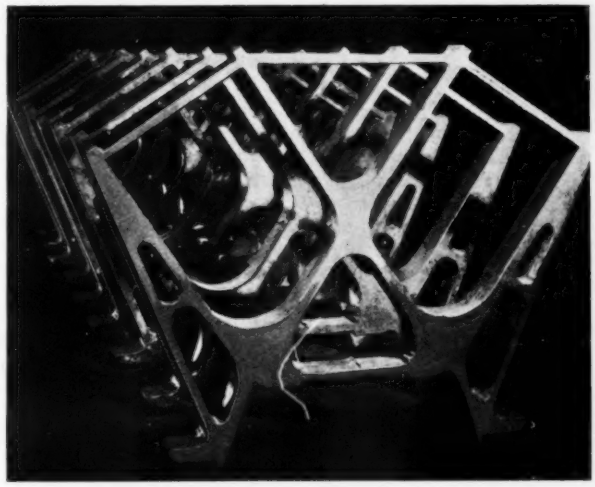
High-carbon molybdenum wheels of the following analysis were therefore adopted: carbon 0·58 to 0·73; manganese 0·60 to 0·75; phosphorus not over 0·04; sulphur not over 0·05; silicon 0·15 to 0·25; molybdenum 0·20 to 0·30. These wheels gave about the same service as the low-carbon, and as a result of the poor performance of the so-called low-carbon and high-carbon-molybdenum wheels, a change was made back to the former specification of what was termed a plain carbon wheel, but with a 2-in. rim thickness. As a result, thermal checking and shelling was practically eliminated and the life of these wheels increased from 84,000 miles to 142,000 miles.

These wheels were all equipped with the standard A.A.R. axle, with the following analysis: carbon 0·40 to 0·55; manganese 0·60 to 0·90; phosphorus not over 0·045; sulphur not over 0·05; silicon not less than 0·15; nickel not over 0·25; chromium not over 0·15. These have been very satisfactory and there are a number of axles in service that have made over 600,000 miles. The mounting and dismounting of power-truck wheels is all handled at Aurora shops, where the axles are given the magnaflux test each time the wheels are removed for renewal.

Engine Bearings

After several main bearing stud failures, the crankshaft main bearing caps and the foot members of the crankcase bearings were serrated so there would be no movement of the main bearing caps. On the connecting rods the upper Bantam roller bearings run approximately 200,000 miles before they have to be renewed; on the lower end the first bearings were primarily 98 per cent. lead, and ran approximately 245,000 miles between renewals. With a later bronze-type bearing with a high lead content it is expected that over 500,000 miles will be obtained between renewals. The main crankshaft bearings are renewed every 400,000 miles, at which they show small shelled-out spots.

So far it has not been necessary to completely regrind any of the crankshafts. During the combined mileage up to May 1, 1939, of 3,168,158 on the four large engines,



Welded steel crankcase and engine framing of Winton 16-cylinder 1,200 b.h.p. engine

two crankshafts were renewed, one because a crankpin bearing had been turned undersize after failure of the connecting-rod bearing, the other because of an incipient crack developing after the crankpin had been ground and the sharp edges of the oil hole had not been rounded and polished.

On the small trains, up to May 1, 1939 the four 600 b.h.p. locomotives had averaged 874,524 miles each during which time the wear on crankshaft bearings was less than 0·009 in. It had not been necessary to regrind any of these shafts. Past experience indicates that a life of at least 1,500,000 miles per crankshaft can be expected before reconditioning is necessary.

Piston Troubles

At the beginning there were a number of piston failures, mainly due to improper design and to an alloy which had not been perfected for such exacting service as on a two-stroke diesel engine. After considerable research and development, pistons were made of a different alloy, and the interior and ring-land construction was changed to obtain more even expansion and better heat dissipation. Later on forged pistons were tried out with satisfactory results, but in order to make still further progress experiments are being made with the latest type of cast piston. With the exception of piston rings sticking in the second ring groove from the top of piston, ring troubles have been nil. During the accumulated mileage up to May 1, 1939, of 6,666,254, only 21 cylinder liners have been reground $\frac{1}{32}$ in. oversize. At the beginning, quite a number of liners were replaced due to defects in the castings; the liners that did not have any defects are still in service and very few of them have worn beyond 0·008 in. in diameter. When the wear exceeds 0·025 in. at the upper end of liners, they are reground $\frac{1}{32}$ in. oversize and reused with oversized pistons.

A little over a year ago trouble was experienced with

XUM

cylinder heads cracking across the valve bridge. After extensive research it was proved that the failures were due to an air-bound condition in the water-cooling system. In one instance there was a leaky gasket on the air compressor head; this air was trapped in the cylinder head, creating a steam-bound condition, with resultant overheating and cracking of the valve bridge. That air-bound condition was eliminated by the application of ½-in. copper tubing which vents any air in the water-cooling system to the atmosphere. Since that has been done there has been very little trouble with cracked cylinder heads, and so far no cylinder heads have been scrapped for any other reason.

Air Locks in Fuel System

On the original engine considerable trouble was experienced with an air-bound condition in the fuel injection system, due to utilising one manifold as a fuel feed and return. That condition was corrected by the installation of a second manifold to serve as a fuel return only, thereby eliminating any air-bound condition to the adjacent injector or injectors should one become defective. Before making the improvements enumerated above, quite frequently fuel injector failures occurred *en route*. When an injector does become defective it is cut out by the crew in charge and the engine continues to handle the train with little or no loss of time.

The inauguration of diesel locomotives in road service meant the establishment of proper facilities for handling the work, and special fuelling facilities *en route* so that fuel could be taken with very little standing time. Due to the high-speed schedules on which these diesel locomotives operate, it means that most of the stops are only of one or two minutes duration. Fuel must be taken once between Chicago and Denver, and this made it necessary to provide one fuelling station, which was located at Lincoln, Neb., where it is possible to supply 1,700 U.S. gal. of fuel oil in five minutes. As crews are changed at this point very little delay occurs taking fuel over that consumed changing the crews.

Maintenance Facilities and Spare Power

At Chicago and Minneapolis, inspection-pit facilities with drop tables and cranes are provided so that power trucks can be changed in a very short space of time. The spare power truck and all spare traction motors are kept on hand at Chicago, where all of the work of changing power trucks and traction motors is performed, except for the one train which is maintained at Minneapolis; in this case when it is necessary to make a change of motors or power truck, the motors or power truck are shipped to Minneapolis. At Chicago, Minneapolis, and Denver special fuelling and lubricating oil facilities are provided so that engines can be fuelled and crankcase oil changes quickly made. At Denver no special mechanical facilities are provided and no protection power truck or traction motors are maintained. The general repairs on the diesel locomotives are handled at the West Burlington locomotive shop, where no special facilities have been provided. Because of the general character of the diesel engines, most parts that are renewed are purchased to a standard size and usually, with the exception of lifting the diesel engine in and out of the cab, the parts can be lifted by hand.

With the two 1,800 b.h.p. and the two 3,000 b.h.p. diesel locomotives operating a total of approximately 3,850 miles a day, some spares necessary must be provided. When these services were started it was decided not to purchase additional diesels, but to remodel and modernise four of the Hudson-type steam locomotives and build one additional new Hudson-type locomotive. These locomotives were modernised to the extent of equipping them with roller bearings on all wheels and valve motion, applying lightweight reciprocating parts and lightweight roller bearing rods.

In addition to furnishing spare and emergency power for diesel operation, these steam locomotives are assigned to regular trains operating over the same territory as the diesels; for instance, two streamlined Hudson-type locomotives operate daily between Chicago and Minneapolis; one locomotive has an entire day layover at St. Paul every day and one has an entire day layover at Chicago, and these locomotives furnish the necessary protection for the operation of the diesel trains between Chicago and Minneapolis. Three of the modern type locomotives are operated on the Aristocrat train between Chicago and McCook, a total of 779 miles, and this provides the necessary protection on the west end of the railroad every day and also makes it possible to protect the diesel trains *en route* between Chicago and McCook. One of these locomotives lays over every day at McCook, one is *en route* and one lays over at Chicago every night.

Swiss Local Railcar Results

SINCE 1923, the Val de Travers Railway, a short local line near the French frontier of Switzerland, has operated two diesel railcars which incorporate parts of the cars supplied in 1914 by Sulzer to the Prussian and Saxon State Railways. The power unit of each car is a six-cylinder vee 200 b.h.p. Sulzer four-stroke engine mounted above the leading six-wheeled bogie, and on the trailing four-wheeled bogie two traction motors drive the wheels through a jackshaft. Judged by modern standards the design of these cars is distinctly cumbersome: but on a short line with low speeds and an infrequent train service they have shown good operating and financial results. The figures for the year 1937 are shown in the attached table.

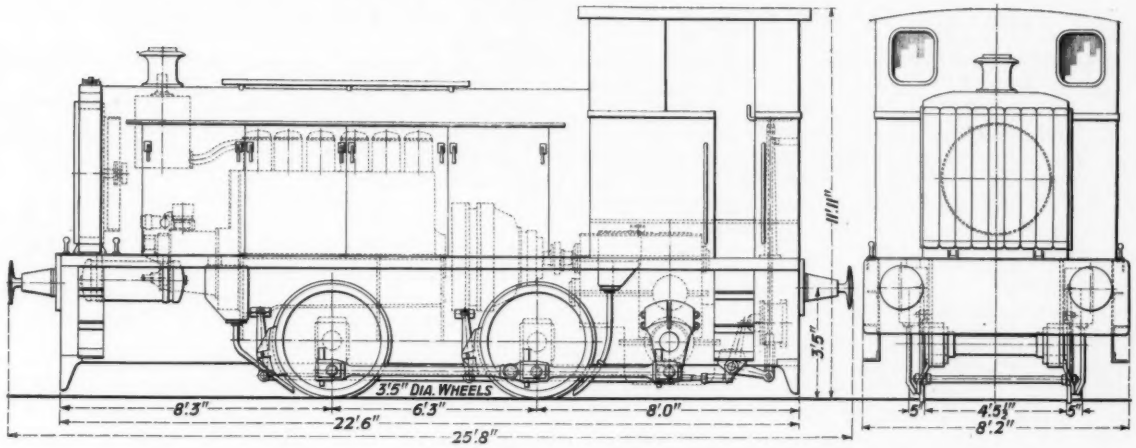
COSTS OF STEAM AND DIESEL TRACTION FOR THE YEAR 1937, VAL DE TRAVERS RAILWAY

	Diesel 2 railcars	Steam 4 locomotives
I Expenses (in Swiss francs)—		
(*a*) Fuel	7,146·10	24,913·37
(*b*) Lubricating oil	1,766·0	928·63
(*c*) Staff	9,278·0	18,343·0
(*d*) Labour charges for upkeep and repair	3,290·78	2,553·13
(*e*) Labour charges for heavy overhaul	—	*4,531·25
(*f*) Material for maintenance and running repairs	2,331·51	2,157·29
(*g*) Material for heavy overhaul	—	*2,375·38
Total, including heavy overhaul	23,812·39	55,802·05
Total, excluding heavy overhaul	23,812·39	48,895·42
II Total train-km.	58,365	70,931
III Tonne-km.	3,986,081	6,158,807
IV Number of days out of service—		
For running repairs and maintenance	120	90
For heavy overhaul	—	*365
V Cost—		
Fuel and lubricating oil per train-km.	Fr. 0·15	Fr. 0·36
Fuel and lubricating oil per tonne-km.	,, 0·0022	,, 0·0041
Running cost per train-km., including heavy overhaul	,, 0·40	,, 0·78
Running cost per train-km., excluding heavy overhaul	,, 0·40	,, 0·68
Running expenses per tonne-km., including heavy overhaul	,, 0·0059	,, 0·0090
Running expenses per tonne-km., excluding heavy overhaul	,, 0·0059	,, 0·0079
Km. run since placed in service	Railcar BCm8	360,509
	,, BCm9	373,873
Average daily run in km. since going into service	,, BCm8	83
	,, BCm9	87

* Locomotive No. 6 out of service the whole year for heavy overhaul.

NORWEGIAN RAILCAR EXTENSION.—The ten new 350 b.h.p. railcars (see issue of this Supplement for February 17 last) and the four 1,200 b.h.p. triple-car diesel trains (see issue of June 9) now being constructed for the Norwegian State Railways are understood to be the precursors of a wider use of railcars, replacing branch line trains and replacing or supplementing main line expresses. A construction programme is being drawn up now, and it is hoped to have all the proposed vehicles in service by the end of 1943.

Diesel Shunting Locomotives for Steel Works

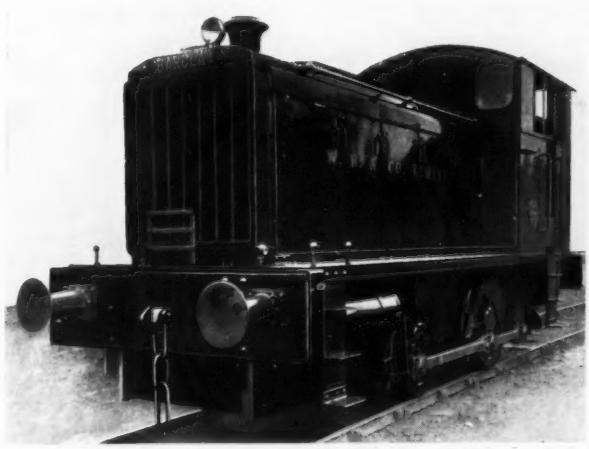


Layout of 34½-ton industrial shunter equipped with Westinghouse brake and having duplicated driving controls in the cab

AMONG the locomotives built by Andrew Barclay, Sons & Co. Ltd. are two four-wheeled diesel units now in use at the Parkhead steel works of Wm. Beardmore & Co. Ltd. These locomotives are unusual, among recent machines, in being equipped with Beardmore light-weight oil engines; the engines actually installed were built some years ago at Dalmuir works, before Beardmore gave up the railway and transport oil engine industry. The engines used have six 8¼ in. by 12 in. cylinders and are set to give 260 b.h.p. at 700 r.p.m.—the maximum required by the duties at Parkhead. The older engines of the same type used in locomotives and railcars were set to give up to 375 b.h.p. at 900 r.p.m. The crankcase is a steel casting which comprises also the cylinder block; the wet type liners are of special steel, and in them run aluminium alloy pistons. The hardened steel camshaft is gear driven, and is carried in a tunnel cast in with the top part of the cylinder block. A double-pump forced lubrication system is included. Beardmore fuel pumps and atomisers are used, and air starting equipment is embodied. The gear drives from the crankshaft to the camshaft, governor, water pump and other auxiliaries are housed in a double-walled aluminium casting.

The transmission comprises a Vulcan-Sinclair fluid coupling, a three-speed Traction gearbox, and Tele-change pre-selective control, all of which were developed by the Hydraulic Coupling & Engineering Co. Ltd. The gearbox itself was actually constructed by Beardmore in conjunction with David Brown & Sons (Huddersfield) Ltd., and gives track speeds of 4, 7½, and 12 m.p.h. at top engine revs. The maximum tractive effort on the bottom gear step is 19,800 lb. The Traction gearbox has constant-mesh gears and dog clutches, with baulking rings to prevent engagement except on synchronism. An auxiliary friction clutch operating in parallel with the top-gear dog clutch is used during changing-up, and gives but a slight drop in tractive effort during the gear-change period.

The mechanical portion is of simple design and is robustly constructed in order to gain a factor of adhesion of approximately 4, and to withstand the shocks of normal heavy yard shunting. A hand brake supplements the Westinghouse apparatus, and gravity sanding is fitted to the outsides of all four wheels. The sides of the engine bonnet can be opened practically all the way down by four big removable doors.



Barclay's biggest diesel shunting locomotive

RAILCARS FOR SPEED.—In the summer timetables of 1938 the State-owned railways of France, Holland, Italy, and Belgium had trains covering a daily mileage of approximately 22,200 miles at start-to-stop speeds in excess of 60 m.p.h.; of this total railcars were responsible for 8,975 miles, of which French vehicles were responsible for 5,920 miles, Dutch railcar-trains for 1,525 miles, Italian railcars for 1,322 miles, and Belgian twin and triple railcars for 208 miles. In general, these mileages have been increased considerably with the 1939 summer timetables, the exception being on certain French business services. On the German State Railway in 1938 the high-speed railcar-trains covered 4,884 miles a day at start-to-stop speeds of 60 m.p.h. and over, compared with 4,039 miles by steam and electric traction.

XUM

Fully-Automatic Control of Mechanical Transmission

Latest type combines simplicity with the ability to work in multiple-unit with railcars equipped with hydraulic and electric transmissions

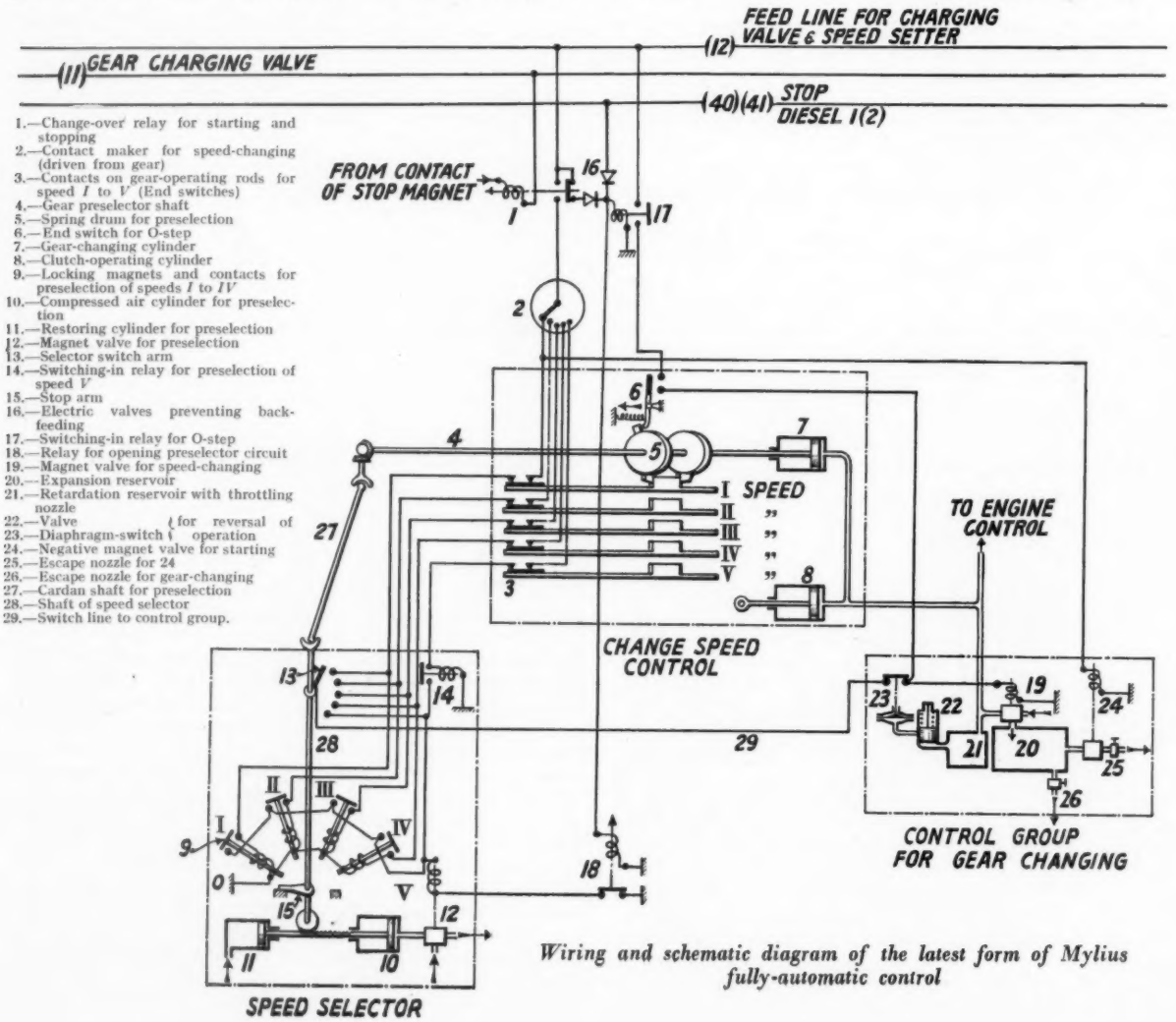
SUPPLEMENTING the descriptions of various forms of control for Mylius mechanical transmission given in the issue of this Supplement for June 9 last, some notes are given below on the latest form of fully-automatic control, which has been developed more particularly for the German State Railway, to permit the operation in multiple-unit of diesel-mechanical railcars along with diesel-hydraulic or diesel-electric vehicles. The control arrangement can easily be adapted to railcars of other lines.

Gear-Changing and Preselection

The accompanying drawing shows the connections for one gearbox. The usual controller is provided at the driver's position (not shown) for the regulation of the fuel supply to the engine and for switching the drive in and out. Gear-changing is actuated by the contact-maker *2* which permits the engagement of the appropriate gear, according to the speed of the vehicle. Preselection of the gear to be used is effected by means of the speed-selector unit, the selected gear being then synchronised and engaged by the control group.

Turning the controller from position 0 to 1 connects the line (*11*) with the return. Voltage is thus applied to the coil of the change-over relay *1 via* the closed auxiliary contacts at the stop-magnet of the railcar. The movement of relay *1* connects the live line (*12*) to the contact maker *2*. The latter is driven from the gear but is still in the rest-position, *i.e.*, the first-speed gear is free for engagement. Current flows *via* the end contact *3/I* on the gear rod *1* to the speed selector, and operates the locking magnet *9/I*, thus completing the circuit of the magnet valve *12*. The valve *12* being thus opened, compressed air enters the cylinder *10*, and the movement of the piston turns the shaft *28*, by a rack and pinion gear, until the stop arm *15* engages with the lowered lock *9/I*. The selector switch *13* then switches current into the control group *via* the line *29*. The shaft *28* being connected to the preselector shaft *4* by the cardan shaft *27*, the spring drum *5* is simultaneously set with its nose on the gear-operating rod *1*.

1.—Change-over relay for starting and stopping
2.—Contact maker for speed-changing (driven from gear)
3.—Contacts on gear-operating rods for speed *I* to *V* (End switches)
4.—Gear preselector shaft
5.—Spring drum for preselection
6.—End switch for O-step
7.—Gear-changing cylinder
8.—Clutch-operating cylinder
9.—Locking magnets and contacts for preselection of speeds *I* to *IV*
10.—Compressed air cylinder for preselection
11.—Restoring cylinder for preselection
12.—Magnet valve for preselection
13.—Selector switch arm
14.—Switching-in relay for preselection of speed *V*
15.—Stop arm
16.—Electric valves preventing back-feeding
17.—Switching-in relay for O-step
18.—Relay for opening preselector circuit
19.—Magnet valve for speed-changing
20.—Expansion reservoir
21.—Retardation reservoir with throttling nozzle
22.—Valve (for reversal of
23.—Diaphragm-switch (operation
24.—Negative magnet valve for starting
25.—Escape nozzle for 24
26.—Escape nozzle for gear-changing
27.—Cardan shaft for preselection
28.—Shaft of speed selector
29.—Switch line to control group.



Wiring and schematic diagram of the latest form of Mylius fully-automatic control

Excitation of the magnet valve *19* in the control group admits compressed air to the gear-changing and clutch-operating cylinders *7* and *8*. The first-speed gear is moved to the synchronising position and the main clutch is disengaged. At the same time, throttled air flows into the retardation reservoir *21* and to the valve *22*. After about one second (the synchronising period) the diaphragm switch *23* receives compressed air and opens the circuit of the magnet valve *19*. Air then flows from the cylinders *7* and *8* into the expansion reservoir *20*, and the sudden decrease in pressure (from about 70 lb. to 20 lb. per sq. in.) engages the first-speed gear. As the air pressure falls further, by flow through the escape nozzle *26*, the nozzle *25* being meanwhile closed by the magnet valve *24*, the main clutch engages smoothly and the vehicle is set in motion.

As the first-speed gear engages, the end contact *3/I* interrupts the operating current and the speed selector returns at once to its initial position and is ready for the next operation. The next gear-change, *e.g.*, from first to second, (I to II speed), is effected by the contact maker *2* immediately the appropriate speed is reached. Pre-selection and engagement of the gear are as before, but the main clutch engages more rapidly, the escape nozzle *25* now being opened as well, so that air escapes more quickly from the expansion reservoir *20*.

The *0*-step or disconnection of the drive is effected either by turning back the controller to *0*, or together with the stopping of the engine. In the first case, current is cut off from the change-over relay *1* and the latter closes a feed contact from line (*12*) for the relay coils *17* and *18*. In the second case, these relay coils are excited from the stop line (*40*). The relay *17* operates and allows current to flow *via* end contact *6* to the magnet valve *19*. The switching operations are as in gear-changing, and on their completion the contacts *6* interrupt current flow to valve *19*. The relay *18* enforces rapid return of the speed selector by interrupting the return lead from the magnet valve *12*.

Simultaneously with the changing of the gears, the fuel supply to the engine is reduced to that required for running light. This prevents an undesirable rise in speed during the short period of disengagement of the main clutch, and also brings the engine to the most favourable speed for the engagement of the next gear. For this purpose, it is arranged that a suitable pneumatically-operated device, mounted above the driver's fuel regulator, receives compressed air simultaneously with the gear-changing cylinder *7*. Air escapes from the over-riding regulator as soon as the gear-changing operation is completed, and the engine then again receives the fuel supply as determined by the driver.

* * *

An amplification of the description of the Mylius semi-automatic control system published in the issue of this Supplement for June 9 may fittingly be given here. Referring to Fig. 3 on page 88 of that issue, the horizontal wire at the top is used to put the gearbox in neutral in case of emergency. If, for example, the lubrication pump of one engine stops working and the oil pressure drops, the gearbox corresponding to this engine must be put into neutral, and this is done by passing the current through the wire in question. In the same illustration, relay *27* in the circuit prevents any gear-step chosen by the driver's push button from influencing the preselecting motor. The rectifiers *30* prevent the neutralising current to the engine out of commission affecting the operation of any other gearbox in the railcar or railcar-train formation. The relay *V* remains open until the push-button *v* is operated, and prevents any current coming from one of the push-button wires flowing back into push-button wire *5* in the event of relay *27* being open. Only eight wires through the inter-car jumpers are required by this Mylius control.

RAILCAR TRACTION IN POLAND

THE Polish State Railways have used railcars for some years, and these run on standard-gauge and narrow-gauge tracks. In general, the mechanical portions have been built by Polish makers, and the engine and transmission equipment supplied by foreign makers, or in some instances built in Poland under foreign licence.

On the State lines the standard-gauge cars are grouped as (*a*) four-wheel and eight-wheel cars having a top speed of 75 km.p.h. (46 m.p.h.); (*b*) bogie cars with top speeds between 75 and 100 km.p.h. (46 and 62 m.p.h.); and (*c*) bogie cars with top speeds varying from 100 to 130 km.p.h. (62-81 m.p.h.). The narrow-gauge (760 mm.) cars are all of one classification, and have a top speed of 60 km.p.h. (37 m.p.h.). A Saurer 12-cylinder vee engine is to be used for main-line cars, but the present motive power of the Cegielski cars is two 150 b.h.p. Saurer engines, one on each bogie, and driving the wheels through Mylius mechanical or Voith hydraulic transmission. Another main-line car has two 210 b.h.p. eight-cylinder vee Simmering engines and electric transmission, and there are five Austro-Daimler pneumatic-tyred cars, each with two 125 b.h.p. M.A.N. engines and Voith hydraulic drive. The slower-speed bogie cars have Ganz, Saurer, and Ebermann engines, and Ganz, Mylius, or electric transmission.

The main-line cars operate services between Warsaw and Lodz; Warsaw and Kattowitz *via* Czestochowa; Warsaw and Cracow *via* Radom; Kattowitz and Cracow; Cracow and Zakopane; and Borystaw—Lwow—Tarnopol. Most of the slower-speed standard-gauge diesel cars are centred on Wilno, but some operate in Polish Silesia, south of Kattowitz. The narrow-gauge vehicles operate over more than a score of branch lines throughout the country. The latest main-line cars are arranged for multiple-unit control, and have been provided with four comfortable seats across the width of the car instead of five as previously. Buffet-bars are installed, as the main-line stops generally are too short for the usual Continental method of re-victualling to be effective.

A monthly mileage of about 155,000 is made by the standard-gauge diesel railcars, and about 16,000 miles by the narrow-gauge vehicles. The operating cost of the 300 b.h.p. double-engined diesel-mechanical cars averages about 91 zlotys per 100 train-km. exclusive of interest and depreciation charges, but including maintenance and repair. The corresponding costs of the hydraulic transmission cars of the same power are a good deal lower, but the services (centred on Lwow) are not at such a fast speed as those in the Warsaw area worked by the geared drive cars, and the cars are newer. The ten 100 b.h.p. Saurer-engined cars shedded at Wilno, and with 40 seats on a tare weight of 15½ tons, cost about 52 zlotys per 100 train-km. to operate, and this cost has remained almost stationary over a number of years.

The construction of numerous railcars powered by diesel engines is envisaged by the State Railways authorities over the next few years, in particular some triple-car trains to run between Warsaw and Gdynia in a time not exceeding four hours. Other single cars, worked in multiple-unit when required, are proposed in order to give fast business services between Warsaw and all the principal towns.

XUM

New British Diesel Locomotives

COMBINING the best features of both the Armstrong-Whitworth and English Electric locomotives set to work in 1936, the score of 350 b.h.p. diesels now being introduced into big marshalling yards on the L.M.S.R. comprise mechanical portions built at the company's Derby works, and engine and transmission equipment supplied by the English Electric Co. Ltd. The single traction motor with geared jackshaft and rod drive, and a method of control enabling speeds of 1 m.p.h. or less to be maintained evenly on humps, were features of the earlier Armstrong-Whitworth locomotives.

Power is provided by a six-cylinder English Electric engine set to give a maximum of 350 b.h.p. at 685 r.p.m., and fed with fuel by a C.A.V.-Bosch pump. Both the circulating water and engine lubricating oil are cooled in a Spiral Tube radiator on the front of the bonnet. The main fuel tank has a capacity of 586 gal. and the service tank 75 gal. A 250-kW d.c. generator is directly coupled to the main engine, and the two are supported as one unit on three pedestals with rubber pads between the feet and the locomotive frame.

Compared with the 1936 locomotives the maximum tractive effort has been raised by 17 per cent. to 35,000 lb. and the weight by 8 per cent. to 55¼ tons. The maximum axle load is 18·9 tons and the top speed 20 m.p.h. Westinghouse brakes, with self-lapping driver's valve, are incorporated, and air sanding is fitted. The wheels are 51 in. in diameter, the wheelbase is 15 ft. 9 in., and the overall length 31 ft. 4½ in. Wide shunters' steps are fitted at the front for use in flat marshalling yards, and have vertical sockets for the shunting poles.

Interior of cab showing duplicated controls, meter and gauge board, speedometer, and, at the top left, the gauge for the main fuel tank

One of the L.M.S.R. 350 b.h.p. diesel shunters recently introduced in Toton mineral yard

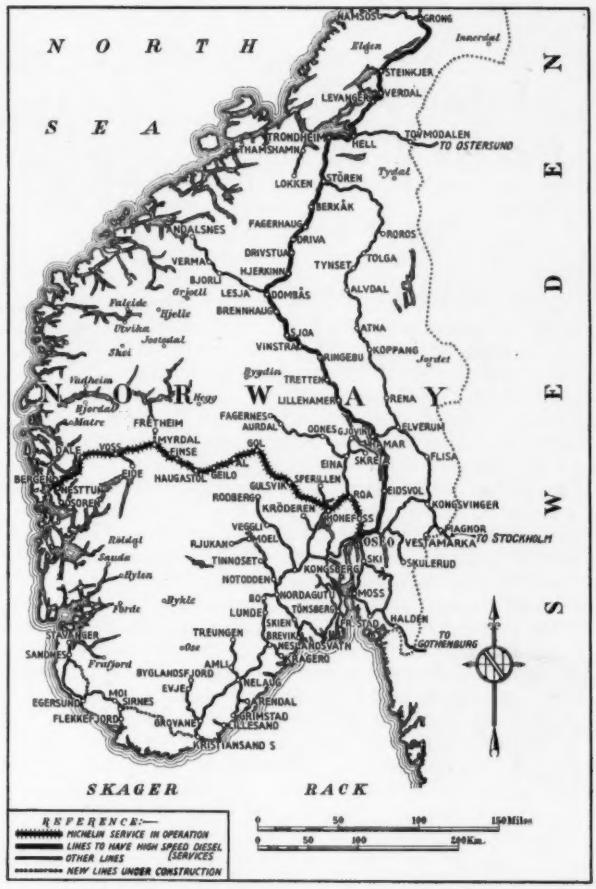
Accelerated Railcar Service in Norway

Summer service over Oslo-Bergen mountain line averages 36 m.p.h. for 306 miles including all stops

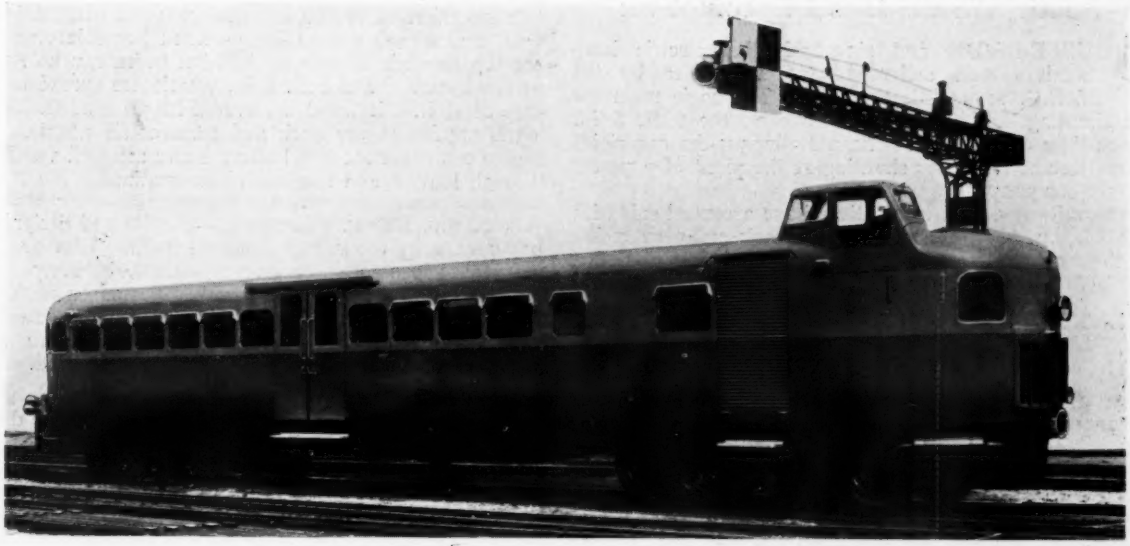
THE first regular fast-speed railcar service in Norway is now in operation between Oslo and Bergen. It is intended as a summer service only, and will continue running until September 6. Inaugurated by the Norwegian State Railways in conjunction with A.S. Lynturene (Lightning Tours Company), the service is intended to give a rapid daylight journey between Oslo and Bergen, to enable passengers from and for the Bergen—Newcastle boats to view the scenic wonders of the route. A direct night train connects with the boats arriving at Bergen, but by stopping at that town overnight, passengers can reach the Norwegian capital in 8 hr. 25 min. the next day. The up railcar leaves Bergen every Sunday, Tuesday, and Thursday, and the down railcar leaves Oslo every Monday, Wednesday, and Saturday, running to the timetable shown below. The fastest steam train takes 10 hr. 20 min., and most of them 11 hr. or more.

14·00	dep.	Oslo	arr.	22·38
17·11	,,	Gol	dep.	19·30
18·18	,,	Haugastol	,,	18·21
18·42	arr.	Finse	dep.	17·55
19·12	dep.		arr.	17·25
19·46	,,	Myrdal	dep.	16·53
20·38	,,	Voss	,,	15·57
22·33	arr.	Bergen	dep.	14·00

All seats in the Lightning railcar have to be reserved in advance, and the fares are as for second class single tickets from Bergen to Oslo. Return-ticket holders and those holding tickets at reduced rates must pay a supplement, and a supplement of kr. 16·40 is payable by holders of through tickets from England to Oslo. A standard 56-seater pneumatic-tyred Michelin railcar obtained from the ex-P.L.M. section of the French National Railways is used to maintain the service, and as it has no refreshment facilities a stop of 30 min. is made at Finse for dinner. The line includes long grades of 1 in 46-60 and a summit 4,200 ft. above sea-level. A gradient profile was published in our issue of February 17 last.



Map showing the route of the Michelin car and the future routes of the diesel trains now under construction. Diesel services eventually will operate also over the Oslo-Bergen route

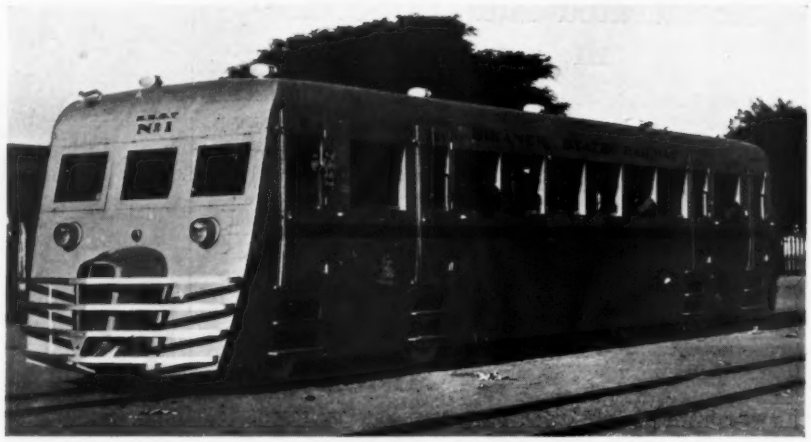


A Michelin rubber-tyred railcar as now used on the Norwegian State Railways

XUM

Indian Railcar for Local Services

Vehicle built in native State workshops shows good financial results



A LIGHT double-bogie, double-engined railcar has just been set to work on the metre-gauge lines of the Bikaner State Railway for operating local and special services. Built at the railway's own works, under the direction of Mr. L. Rigg, the Locomotive & Carriage Superintendent, the car has a seating capacity of 63 third class passengers, and also a small upper class compartment to carry two passengers. As the car is to be used on light branch lines where turntable or triangle facilities are not always available, it was decided to instal two engines, only one of which would work in each direction of running. As the engines used are of the standard Ford-V8 type, their cost is very small, and by using only one engine at a time, the extra initial and maintenance expenses of remote control have been avoided, and the construction simplified.

The engines are carried on the underframe and drive the inner axles of the adjacent bogies. In order to take up the vertical movement of the body and the lateral movement of the axles on curves, the driving shaft has been extended to bring the universal couplings below the bogie centre, where they are bolted to a plate suspended from the body. Thus the torque tube to the driving axle functions in the same way as it does in a road vehicle. At the top track speed of the car the engine speed is a little higher than that normally used in road practice and therefore the cooling system has been augmented by a secondary radiator for each engine.

The bogies have a wheelbase of 8 ft. and are pitched at 23 ft. 8 in. centres. The side members are 6 in. high with 3-in. channels bolted direct to the axles, and two cross members are provided for the spring suspension. Coil springs to take the side play are inserted between the body and the bogie members. The body simply rests on four inverted laminated springs hung from the bogie. Vacuum brakes are fitted, and actuate Ford standard brake drums on all axles. An emergency hand brake is fitted at each end.

The tare weight of the car is 7¾ tons and the gross weight about 11 tons. The acceleration on level track is from rest to 30 m.p.h. in one minute and to 45 m.p.h. in two minutes. The scheduled speed on the Sri Kolayatji branch is 30 m.p.h. start-to-stop and the petrol consumption averages 8·9 m.p.g. The capital cost of the car was Rs.17,000 and, after making ample allowance for depreciation and interest charges, it has been earning net revenue at the rate of Rs.2,500 a year, which is equivalent to 14½ per cent. of the capital cost.

South African Diesel Locomotives

DOUBLE-BOGIE and six-wheel diesel-electric locomotives were delivered to South Africa by the A.E.G. some little time ago. The bogie units are for shunting and light freight work on the 3 ft. 6 in. gauge lines of the South African Railways; the one rigid-frame locomotive is for shunting at the plant of a power supply company.

The railway-owned locomotives have a central cab with a 265 b.h.p. M.A.N. engine at each end; on an extension of the welded steel underbed of each engine is carried a 110 kW main generator and a 12 kW auxiliary generator. The control is on the A.E.G. full-load system, a development of the Lemp principle. Each generator feeds two forced-ventilated nose-suspended traction motors coupled permanently in series. A maximum tractive effort of 35,200 lb. can be exerted, giving a factor of adhesion of 4·2 against the working order weight of 66 tons. The bogies, with a wheelbase of 8 ft. 6 in., are pitched at 21 ft. 10 in. centres, and the overall length is 46 ft. 8 in. The top speed is 25 m.p.h., and 1,000-ton trains can be hauled at low speeds.

The six-wheel locomotive is equipped with one M.A.N. 265 b.h.p. engine and three forced-ventilated nose-suspended traction motors. There is a driving cab at one end only. Against the weight of 40½ tons the maximum tractive effort of 17,600 lb. gives a factor of adhesion of 5·15, and as with the railway-owned bogie locomotives, the top speed is 25 m.p.h. 600-ton trains can be hauled at low speeds. The 3 ft. 6 in. wheels are spread over a base of 11 ft. 4 in., and the overall length is 31 ft. Sanding is applied to the back and front of all wheels. The engine compartment and battery boxes are well ventilated through louvres and fine mesh wire gratings.

3,000 H.P. DIESEL PROPOSALS.—Studies and designs are being made by the French National Railways for a single-unit diesel locomotive to give at least 3,000 b.h.p. The designs are to be suitable for either passenger or freight working, and a wheel arrangement of either 2-Do-2 or 2-Eo-2 is proposed. Such a unit would form the most powerful single-unit diesel locomotive in the world.

GERMAN RAILCAR WORKING.—The operation of internal-combustion engined railcars (nearly all of which are diesel) on the standard-gauge lines of the German State Railway has increased from 5,635,000 train-miles in 1934 to 10,285,000 train-miles in 1935, to 15,691,000 in 1936, to 18,900,000 in 1937, and to 21,746,000 in 1938. These figures represent 5·8 per cent. of the total passenger train-miles on main lines and 9·9 per cent. of those on branch lines.

NOTES AND NEWS

American Light Railcars.—The American Car & Foundry Company is now offering railcar-trains powered by petrol or oil engines of the horizontal type, located beneath the floor, and driving the axles through either geared drive or hydraulic torque converters.

French Railcars.—Some publicity has been given in England lately to a number of diesel-electric railcars said to have been set to work recently on the Grenoble-Marseilles line of the French National Railways. Actually nine of these railcars were introduced on that route three years ago, and were described in the issue of this Supplement for October 30, 1936. Last year an order for another 10 cars, with modifications to the original design, was placed, but these cars are not yet delivered.

Railcars for the East Indies.—Three triple-car diesel-mechanical trains are to be built by Beijnes N.V., of Haarlem, for the 3 ft. 6 in. gauge lines of the Netherland Indian State Railways. They are to be equipped with two Thomassen engines pressure-charged on the Büchi system to give a maximum individual output of 300 b.h.p. The engine torque is to be transmitted to the wheels through a Vulcan-Sinclair fluid coupling and an S.L.M.-Winterthur gearbox. Seating for 78 third class, 24 second class, and eight first class passengers is proposed. Prospects of this equipment were reported in the issue of this Supplement for September 2, 1938.

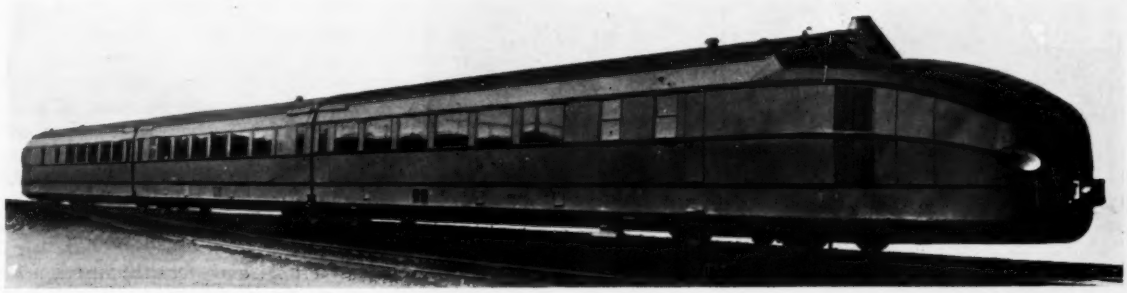
A.E.C. Shunter Service.—The A.E.C. 78 b.h.p. loco-tractor described in the issue of this Supplement for December 23, 1938, has now been in operation in and around the maker's works at Southall for eight months, during which period it has handled 1,462 loaded and 139 empty trucks inwards, and 616 loaded and 972 empty trucks outwards. The actual service hours have been 563, and the actual mileage covered 976. Fuel consumption has averaged 0·492 gal. per service hour. Tests have also been made on the G.W.R. Southall-Brentford branch, and this 13¼-ton locomotive was found capable of hauling a 77-wagon train weighing over 900 tons at a speed of 2 to 3 m.p.h.

American News.—The Kansas City Southern Railroad has ordered a 1,000 b.h.p. diesel-electric shunting locomotive, and the Chicago, Rock Island & Pacific Railroad has ordered a further 2,000 b.h.p. streamlined diesel-electric locomotive for use on the Rocket trains; both are to be of the Electro-Motive type with Winton engines. On June 18, the two City of Denver streamlined diesel trains of the Union Pacific Railroad completed three years of service, with an aggregate mileage of 2,294,058, equivalent to 383,500 miles a year per train. The Phelps Dodge Corporation has ordered another diesel locomotive, this time of 600 b.h.p., and the Florida East Coast Railroad has ordered two 2,000 b.h.p. Electro-Motive express passenger diesel locomotives. A total of 14 Budd stainless steel cars have been ordered by the Florida East Coast, to make up the trains to be hauled by the 2,000 b.h.p. diesel locomotives. The Atlantic Coast Line has ordered two 1,000 b.h.p. Electro-Motive diesel locomotives for hauling light-weight seven-car stainless steel trains now being built by Budd. The three 2,000 b.h.p. locomotives by the same maker to haul the Denver Rocket trains of the Chicago, Rock Island & Pacific Railroad have been delivered. They weigh 93 English tons, have an overall length of 71 ft. 4 in., and a maximum safe speed (electrical equipment) of 117 m.p.h. It is expected that the trains for this service will be ready in September.

Traction Gearbox.—Although the design of the Traction type gearbox and Tele-change preselective gear, as fitted to the Hudswell Clarke locomotive for Shell-Mex, described in our July 7 issue, was evolved by the Hydraulic Coupling & Engineering Co. Ltd., the gearbox in this particular case was designed and manufactured by Bostock & Bramley Limited, and the Tele-change units were manufactured by Hudswell, Clarke & Co. Ltd.

Mylius Transmission. — A British company — the Mylius Gears Co. Ltd.—has been formed to look after the sales and manufacture of the well-known Mylius mechanical transmission in the British Empire. The office of the company is at 60, Queen Victoria Street, London, E.C.4, and the manager is Mr. A. M. Porter. The gearboxes are to be built by David Brown & Sons (Huddersfield) Ltd.

German Diesel Speed Record.—A speed of 215 km.p.h. (133·6 m.p.h.) was attained, and 200 km.p.h. (124·3 m.p.h.) maintained for some distance on June 23 by the *Flying Silver Fish*, an experimental three-car train built to the ideas of Kruckenberg and running in trial service on the Reichsbahn. It is powered by two 600 b.h.p. Maybach engines equipped with Büchi pressure-chargers and has hydraulic transmission built by the A.E.G. It will be recollected that the same type of double-axle transmission is available in Great Britain for supply by the Hydraulic Coupling & Engineering Co. Ltd., Isleworth, under licence arrangements with J. M. Voith, Allgemeine Elektricitats-Gesellschaft, and Professor Föttinger, in so far as hydraulic turbo transmissions for diesel rail traction are concerned.



The 1,200 b.h.p. articulated Flying Silver Fish, which made the record of 133·6 m.p.h. on the Berlin-Hamburg line of the German State Railway on June 23

XUM

Narrow-Gauge Locomotives for Special Service

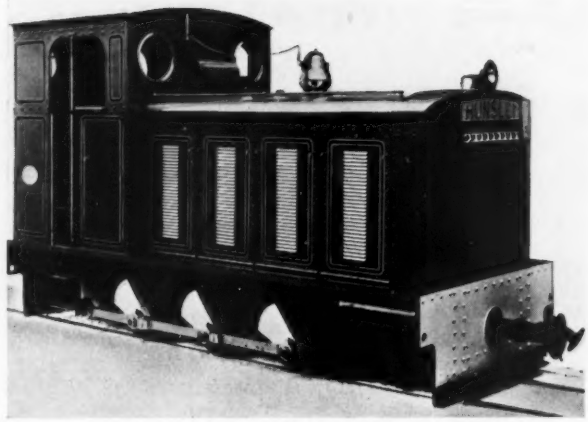
Flame-proof equipment of a comprehensive character is fitted to the engine, electrical equipment, and mechanical portion

FOUR diesel-mechanical locomotives for 3-ft. gauge tracks have just been supplied to an oil refinery in the Near East by the Hunslet Engine Co. Ltd., and are to a design which incorporates every practicable method of making the working safe in an atmosphere which may be charged with pentane and other gas to an extent rendering it highly explosive.

Power is provided by a National MV6 diesel engine which has a maximum output at sea-level of 127 b.h.p. at 850 r.p.m., and a maximum of 106 b.h.p. at the same rotational speed under site conditions, the works being situated over 3,000 ft. above the sea. The detachable cylinder heads include a special form of combustion chamber designed to give efficient combustion over a wide range of load and speed. The inlet and exhaust valves can be removed without disturbing the heads or breaking any pipe joints, and a variable-speed governor allows the engine speed to be controlled anywhere between the limits of 300 and 850 r.p.m.

Special precautions have been taken to maintain the efficient working of the engine in the dusty tropical atmosphere. In addition to a large Vokes Protectomotor air filter, all working parts are protected from the ingress of dust. A large-capacity lubricating oil sump is fitted, and the oil is cooled by circulating it through a portion of the radiator on the front of the locomotive. The radiator itself is composed of Serck sectional elements with Hunslet headers. A separate lubricating oil pump maintains this circulation at a low pressure. Exhaust gas temperature is measured by a thermocouple indicating pyrometer, which gives an accurate indication of great help to the engineer in charge of maintaining the diesel engine, and assists in obtaining the best performance.

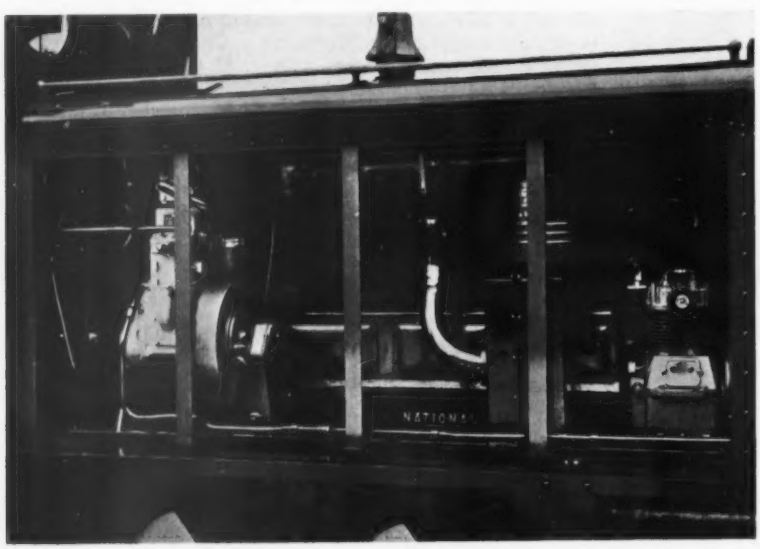
As regards the flame-proof equipment, not only are the engine inlet and exhaust ducts protected by flame-proof grids, of a pattern passed by the Mines Department for use in an explosive atmosphere after exhaustive tests at the Buxton testing station, but before escaping through the grids the exhaust gases pass through the Hunslet patent exhaust gas conditioner (see issue of this Supplement for March 17 last); both the grids and conditioner are made of Austenitic stainless steel throughout, to avoid corrosion, and the inlet air is drawn through the Protectomotor air filter before passing through the flame-traps.



127 b.h.p. locomotive for work in an oil refinery

The engine is started by an auxiliary single-cylinder Ailsa Craig diesel, through a friction clutch and a Bendix drive on to a ring on the main flywheel, this arrangement being of the type which has been installed in many previous Hunslet diesel locomotives over a wide range of power. This Ailsa Craig engine is also protected by an approved type of flame-trap on the induction side, and its exhaust is led into the main conditioner. The auxiliary electrical equipment is also of a flame-proof type tested at Buxton, the centre coupler buffing faces have Ferodo coverings and the brake blocks are of the same material.

The transmission is through a Vulcan-Sinclair hydraulic coupling and Hunslet patent auxiliary clutch and flexible coupling to a robust three-speed gearbox of the maker's own type, which gives track speeds of 3·4, 6·8 and 10·2 m.p.h. in either direction. Ransome & Marles ball and roller bearings and Skefko roller bearings are used in the



Engine compartment of one of the Hunslet locomotives for flame-proof service. To the left of the main National oil engine is the single-cylinder Ailsa Craig diesel engine used for starting purposes. To the right is the Broomwade compressor which supplies air for the brake and for the transmission-operating mechanism. To the left of the compressor, behind the bonnet strut, is the Vokes Protectomoter filter

transmission. The locomotive is able to exert a maximum tractive effort on the bottom gearstep of 9,930 lb., and the adhesion weight of about 22 tons gives a factor of adhesion of nearly 5 to 1. The gearbox is built up of steel plates, and by the employment of stiff shafts, carefully-designed gearwheels, and the use of ball and roller bearings throughout, high transmission efficiencies are obtained. The Hunslet patent pre-selective gear-change mechanism controls the gears; a single hand-wheel speeds up the engine and controls the gears through a series of cam-operated pneumatic valves, which deliver air at a pressure of 50 lb. per sq. in. in correct sequence to the cylinders which control the gears, clutch, and clutch-shaft brakes. The control wheel and all other locomotive controls are fitted at each side of the cab. The final drive to the wheels is through a jackshaft and rods.

Westinghouse straight air brakes are fitted and are controlled by a self-lapping driver's brake valve in the cab; a Broom & Wade compressor supplies air for the brake and gear-change mechanism. Another fitting is an A.T. speedometer in the cab. The wheels have a diameter of 33 in. and are spread over a wheelbase of 7 ft. The length of the locomotive over buffer beams is 18 ft. 9 in., the height 9 ft. 7 in., and the width 7 ft. 9 in.

THE PAINTING OF RAILCARS

The experiences of a correspondent in the protection of fuel and water tanks, and battery boxes

THE necessity for different treatment in the painting of the water tanks of a diesel railcar or locomotive as compared with those of steam locomotives is due to the temperature of the water in the diesel vehicle, which may be at any stage up to boiling point, whereas the water in the tanks of normal steam locomotives is always at a comparatively low temperature. As long as the temperature does not exceed about 80° F., no harm will come to tank surfaces painted in the usual manner, but with temperatures higher than about 100° F. the paint blisters and peels off, enters the pipes, and eventually clogs up one or other of the feed valves or cooling passages. At the same time, corrosion sets in on the bare portions of the tank plates and leakage may follow in a comparatively short time.

At an early stage in the development of diesel railcars, a need was felt for a paint that would remain hard and set irrespective of the temperature to which the water might rise. Various paints were tested under different conditions and degrees of heat, such as raising and lowering the temperature with the plates covered or partly covered, the test being prolonged continuously for well over a week. In most of the tests carried out the paint broke down, leaving the plate surface exposed and the detached film suspended in the cooling stream, where it was liable to create emergency conditions at any time. The preparation ultimately selected was a Bitulac paint containing asphaltum, gum, white spirit, and linseed oil, in suitable proportions; in spite of severe and prolonged tests, not the slightest deterioration was discovered, although the surfaces were subjected to a critical examination.

Fuel Tank Protection

The protection of fuel oil tanks formed another problem for a considerable period. The practice recommended in the early stages, and included in numerous specifications issued to private contractors, was to galvanise the tanks after riveting or welding. It was found to be almost impracticable to make a satisfactory job of a completed unit without serious distortion; galvanising was abandoned, and a search instituted for a suitable paint. Various paints and enamels were tried, in every case without success; the chemical action of the fuel oil ate into the coating and in time flaked it off the whole interior surface. Trouble naturally arose due to the paint lodging in the engine pipes and fuel valves, and an attempt was made to run without treating the plate surfaces in any way at all after these had been thoroughly scaled and cleaned. Difficulties were still encountered, as it was found that rust could not be prevented; this gave rise to similar trouble to that which had previously occurred, but through particles of dislodged rust.

The cure proved to be very simple and inexpensive, though absolutely effective, and was obtained by giving a thoroughly good coat of boiled linseed oil to all inner surfaces after these had been carefully cleaned and freed of rust, scale and moisture. The outer surfaces of these tanks were treated with a synthetic oil-resisting paint of approved quality, as naturally some of the fuel oil was bound to fall on patches of these areas, and cause serious disfigurement to the finished appearance.

The most suitable methods for the treatment of the battery box containers were difficult to determine at first. The difficulty compared with the generally satisfactory state of the boxes in ordinary coaching stock actually arose as the result of a different design of container, those used on ordinary carriages being for the most part formed of wood, whereas those for railcars are of steel plates and sections, wood being employed only for the packing and wedges to locate the various cells. After testing numerous brands of anti-corrosive paints without success, the goal was reached by painting the steel surfaces with a single coat of Anodite rust-resisting primer, followed by two coats of anti-sulphuric enamel. Although on passenger vehicles a measure of success has been achieved with the woodwork by having it heavily impregnated with wax, it was decided to paint the woodwork in a similar manner to that adopted for the steel structure, but with the anti-sulphuric enamels specially graded for wood and steel respectively, and with the rust-resisting primer omitted.

POLISH RAILCAR PROGRAMME.—Preparations are being made to extend considerably the use of diesel railcars on the Polish State Railways, and a total of about 400 cars is envisaged, compared with the 60 to 70 cars of this type now in traffic. At present the diesel cars make a mileage of over 2,000,000 a year.

SOME BRAKING NOTES.—Using both air brakes and electromagnetic track brakes, the 140-ton (gross) triple-car Nord diesel-electric trains of the French National Railways can be stopped from a speed of 87 m.p.h. in 600 yd. and in 24 sec. when running down a 1 in 200 gradient. The 65-ton (gross) Renault twin-car diesel-mechanical sets on the same railway can be stopped on the same grade in 525 yd. and 27 sec. from a speed of 76 m.p.h. when using compressed air brakes only.

SHUNTING LOCOMOTIVE OPERATION

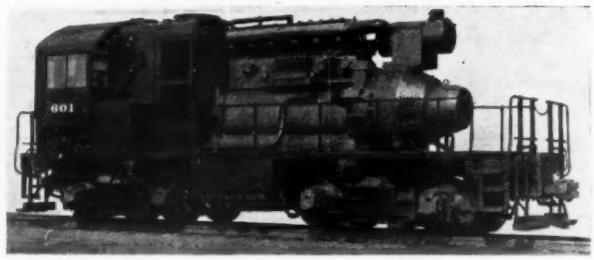
Notes on the costs of heavy 600 and 900 b.h.p. diesel-electric locomotives in America

FROM information supplied by a number of railroads owning 600 b.h.p. diesel-electric switching locomotives with Ingersoll-Rand, Alco, and Winton engines, the Association of American Railroads has been able to compile the attached Table I of repair costs and yearly service records up to the end of 1937. As regards the locomotives belonging to the railroad numbered 3 in the table, the assignment of 78,888 hours for the nine years means 24 hr. a day service for 365 days a year and for 366 days in the leap years included, so that the percentage availabilities of 56-59 need not be viewed pessimistically, particularly as over the nine-year period they mean that the average number of hours in actual service a year has been 5,050. Another notable performance is that of the locomotive on railroad No. 6, which has averaged 6,600 hr. of service a year for over seven years, and at a repair cost which is just about the average for the 51 locomotives covered by the table. Almost as good a result is shown by the last locomotive belonging to railroad No. 9, which has averaged practically 6,000 service hours a year for six years at a repair cost of $0·7135 an hour.

By the courtesy of Mr. Sidney Withington, Electrical Engineer, New York, New Haven & Hartford Railroad, we are able to publish a second table showing the detailed operating costs of the Alco 600 b.h.p. diesel-electric switching locomotives in service on that line. No. 0900 was the first 600 b.h.p. diesel locomotive built by Alco, and since the beginning of 1932 has put in almost 45,000 hr. of service. Sundry changes in the design and equipment have been made, not so much owing to failures, but to bring the locomotive into line with modern practice and to improve its performance. Most of the engine details of this first locomotive are now interchangeable with those of locomotives Nos. 0911-0920 placed in traffic between March and June, 1938.

On the Chicago & North Western Railway a 600 b.h.p. diesel-electric switcher was placed in traffic in 1930, and for the first eight years of its life gave an availability of 86 per cent. The average cost of maintenance and repairs has been $0·58 per service hour, including a shopping for heavy overhauls after about 55,000 hr. of work. At this overhaul the cylinder liners were bored and rebushed, and the original pistons put back. The main bearings were removed for inspection and replaced without repairs, but the big-end bearings were renewed. There have been no major repairs to the generator or traction motors, but the insulations are repainted and rebaked every four years. The fuel consumption has averaged 8·37 U.S. gal. an hour, and the lubricating oil consumption 0·13 U.S. gal. an hour. This locomotive has lower repair costs than other 300 b.h.p. diesel locomotives on the same railroad, and this lower cost is attributed partly to improved design—the 600 b.h.p. unit being acquired at a later date—and to the greater capacity reducing the number of full-load peaks.

Twenty-four hour a day service between monthly in-



One of the 600 b.h.p. Alco switchers, with engine bonnet removed, on the A.T.S.F. Railroad

SERVICE RECORDS OF AMERICAN 600 B.H.P. DIESEL-ELECTRIC LOCOMOTIVES OPERATED BY SELECTED RAILROADS TO DECEMBER 31, 1937

Railroad index	No. of units	Average years in service	Aggregate service years	Hours assigned	Hours operated	Per cent. assignment operated	Lubricating oil		Fuel oil		Repair cost, $			Per cent. repairs for labour	Repair cost per hour $	Average hours operated per unit yr.
							U.S.A. gal. used	U.S.A. gal. per hr.	U.S.A. gal. used	U.S.A. gal. per hr.	Labour	Material	Total			
1	2	3·0	6·0	46,450	37,392	80·50	5,099	0·1364	130,153	3·481	—	—	11,740	—	0·3140	—
	6	4·0	24·0	183,679	153,969	83·83	15,314	0·0995	912,986	5·930	—	—	53,233	—	0·3457	—
	8	4·0	32·0	233,437	185,086	79·29	18,726	0·1012	1,007,945	5·446	—	—	58,299	—	0·3150	6,070
2	6	7·9	47·70	421,560	286,350	67·93	34,981*	0·1701*	2,150,349	7·510	—	—	212,946	—	0·7437	—
	7	2·55	17·5	175,008	129,079	73·76	12,046	0·0933	877,179	6·796	—	—	59,998	—	0·4648	6,370
3	1	9·0†	9·0	78,888	44,373	56·25	10,692	0·2410	350,498	7·899	—	—	69,222	—	1·5600	—
	1	9·0†	9·0	78,888	46,498	58·94	9,537	0·2051	370,725	7·973	—	—	59,480	—	1·2792	5,050
4	1	3·5	3·5	26,923	26,923	100 00	2,239	0·0832	170,669	6·339	7,988	2,679	10,667	74·89	0·3962	—
	1	3·5	3·5	23,210	23,210	100·00	3,167	0·1364	184,865	7·965	10,071	2,129	12,200	82·55	0·5256	—
	1	2·58	2·58	18,795	18,795	100·00	1,542	0·0820	118,598	6·310	5,362	1,320	6,682	80·25	0·3555	—
	1	2·16	2·16	16,239	16,239	100·00	1,251	0·0770	104,196	6·416	5,343	803	6,146	86·93	0·3785	7,255
5	1	5·25	5·25	46,462	34,744	74·78	4,114	0·1184	276,924	7·970	15,905	12,634	28,539	55·73	0·8214	6,620
6	1	7·33	7·33	56,666	48,483	85·56	6,300	0·1299	406,067	8·375	13,761	14,277	28,038	49·08	0·5783	6,615
7	1	2·83	2·83	21,481	19,560	91·06	1,311	0·0670	123,930	6·336	7,833	2,254	10,087	77·65	0·5157	—
	1	3·25	3·25	26,333	25,107	95·34	2,266	0·0903	150,566	5·997	7,627	3,174	10,801	70·61	0·4302	—
	1	1·33	1·33	10,860	10,139	93·36	1,173	0·1157	44,784	4·417	2,664	1,434	4,098	65·00	0·4042	—
	1	1·33	1·33	10,853	9,701	89·39	1,117	0·1151	43,657	4·500	2,802	1,556	4,358	64·30	0·4492	—
	1	1·33	1·33	10,535	9,390	89·13	1,266	0·1348	40,896	4·355	2,818	1,169	3,987	70·68	0·4246	7,340
8	1	1·46	1·46	10,880	10,425	95·82	743	0·0713	62,574	6·002	2,281	714	2,995	76·16	0·2873	—
	1	1·33	1·33	11,014	10,451	94·89	921	0·0882	69,040	6·606	2,292	806	3,098	73·98	0·2964	—
	1	1·46	1·46	10,909	10,440	95·70	673	0·0645	64,827	6·209	2,110	583	2,693	78·35	0·2580	7,370
9	1	1·33	1·33	11,105	8,599	77·43	1,534	0·1784	39,927	4·643	4,045	911	4,956	81·62	0·5763	—
	1	1·16	1·16	10,096	7,685	76·12	1,259	0·1638	36,076	4·694	3,410	453	3,863	88·27	0·5027	—
	1	1·17	1·17	9,928	8,428	84·89	1,256	0·1490	37,649	4·467	2,735	389	3,124	87·55	0·3707	—
	1	1·16	1·16	9,749	6,750	69·24	1,623	0·2404	35,287	5·228	2,945	567	3,512	83·86	0·5203	—
	1	1·0	1·0	8,194	4,115	50·22	1,157	0·2812	25,738	6·255	2,207	448	2,655	83·13	0·6452	—
	1	6·0	6·0	50,284	35,957	71·51	11,429	0·3179	257,431	7·159	13,418	12,237	25,655	52·30	0·7135	6,050
Total	51	—	195·66	1,618,426	1,227,888	75·87	152,736	0·1244	8,093,536	6·591	117,617	60,537	703,072	66·02	0·5726	6,275

* No lubrication records for 1929, 1930, and 1931. † Units in service in 1927—no cost records prior to 1929.

N.Y.N.H. & H.R.R. Diesel-Electric Switching Locomotive Statistics to April 30, 1939.

Locomotive No.	0900							0911		0912		0913		0914	
Year	1932	1933	1934	1935	1936	1937	1938	1939	1938*	1939	1938*	1939	1938*	1939	1938*	1939
Costs:	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$
Repairs	1,512·95	3,683·49	7,613·38	3,377·38	6,594·44	2,873·09	7,054·33	1,650·34	2,439·81	1,091·21	2,073·18	776·37	2,023·20	758·81	1,917·93	738·81
Motormen and firemen	5,652·98	5,718·57	3,791·10	6,222·46	7,613·41	12,142·82	10,129·26	3,475·72	10,188·95	4,639·96	11,265·47	4,742·72	10,294·84	4,505·11	10,533·78	4,485·37
Fuel oil	2,689·17	2,699·54	1,798·61	2,707·10	2,055·14	3,072·06	1,906·87	583·97	1,609·09	687·17	1,734·18	669·86	1,504·66	642·60	1,543·23	622·48
Lubricating oil	737·50	1,354·57	930·29	738·76	611·85	769·05	579·12	234·61	205·35	58·10	255·83	67·89	206·65	78·75	261·22	61·09
Engine house	—	—	—	—	—	—	188·97	121·96	139·29	172·33	162·32	156·57	249·99	149·61	188·58	152·84
Other supplies	127·56	90·54	56·58	90·03	84·29	81·63	68·00	30·54	46·63	14·40	48·41	6·83	58·83	6·83	40·20	6·54
Total	10,720·16	13,546·71	14,189·96	13,135·73	16,959·13	18,938·65	19,926·55	6,097·14	14,629·12	6,663·17	15,539·39	6,420·24	14,338·17	6,141·71	14,484·94	6,067·13
U.S. Gallons fuel oil	46,664	49,684	32,107	45,564	35,428	48,004	37,542	13,436	34,461	15,810	37,215	15,412	32,308	14,784	33,222	14,321
Service hours	6,460	6,645	4,314	6,360	5,290	6,879	5,490	1,869	5,595	2,492	6,180	2,547	5,653	2,419	5,782	2,409

Locomotive No.	0915		0916		0917		0918		0919		0920	
Year	1938*	1939	1938*	1939	1938†	1939	1938†	1939	1938†	1939	1938‡	1939
Costs:	$	$	$	$	$	$	$	$	$	$	$	$
Repairs	1,963·05	941·90	1,758·33	791·07	1,833·81	739·48	1,618·78	712·91	1,673·15	714·52	1,364·33	739·40
Motormen and firemen	10,313·94	4,713·64	9,692·29	4,624·12	9,345·19	4,758·43	8,351·38	4,731·27	9,249·63	4,580·24	6,769·09	4,830·22
Fuel oil	1,475·28	641·55	1,400·30	679·71	1,318·68	659·14	1,160·72	683·87	1,291·82	617·41	932·48	683·86
Lubricating oil	210·58	63·33	279·53	59·70	257·09	80·05	305·72	67·79	268·16	57·40	158·65	36·04
Engine house	192·93	160·35	188·58	152·64	158·29	137·99	181·01	154·60	188·34	157·95	202·70	150·04
Other supplies	39·48	7·87	35·24	6·83	35·16	6·83	35·42	6·83	41·16	6·83	65·35	31·16
Total	14,195·26	6,528·64	13,354·27	6,314·07	12,948·22	6,381·92	11,653·03	6,357·27	12,712·26	6,134·35	9,492·60	6,470·72
U.S. Gallons fuel oil	32,232	14,762	30,454	15,638	29,205	15,164	25,597	15,735	27,655	14,204	20,820	15,734
Service hours	5,651	2,531	5,292	2,483	5,091	2,555	4,537	2,540	5,029	2,459	3,633	2,594

* Locomotive placed in service, March, 1938. † Locomotive placed in service, April, 1938. ‡ Locomotive placed in service, June, 1938.

spection periods, and with daily inspections during the crews' lunch-times, is a feature of the operation of the 11 diesel-electric switching locomotives which have been at work for some time on the Atchison, Topeka & Santa Fe Railroad. These locomotives comprise three of 600 b.h.p. with four-stroke engines; four of 600 b.h.p. with two-stroke engines; one of 660 b.h.p. with a four-stroke engine; and three of 900 b.h.p. with two-stroke engines.

Monthly Examination

At the monthly inspections the entire equipment, including running gear and brakes, is thoroughly inspected, tested, and, when necessary, repaired. The pistons of the Winton two-stroke engines are frequently inspected through the scavenging ports, and if there is no occurrence which makes it necessary to withdraw the pistons earlier, they are taken out every year for a minute examination, and at the same time the cylinder liners and connecting rod bearings are closely examined. No monthly inspection of pistons or bearings are given to the four-stroke engines, and as yet there have been no renewals of pistons or bearings in the units set to work in 1937. At the end of two years the pistons and bearings are to be removed for complete examination, and any desirable renewals or repairs will then be made.

Average Operating Cost Per Hour of 11 diesel Switching Locomotives of 600-900 B.H.P. for the Year 1938, Atchison, Topeka & Santa Fe Railroad

	$
Repairs	0·24
Depreciation	0·53
Crew wages	1·58
Fuel	0·26
Lubricants	0·07
Other supplies	0·01
Enginehouse expenses	0·05
	2·74

The eleven locomotives work 31 eight-hour shifts a day, and have averaged 90·6 per cent. availability; nine of the locomotives are in the Chicago area. One of the eleven is considered as experimental, and its temporary withdrawal from one cause or another, has lowered the average availability of the whole stud. Crankcase oil is changed every 90 days in the 900 b.h.p. engines, and every six months in the smaller engines. It is the opinion of Santa Fe officials that in switching service a heavy overhaul should not be required until such time as the renewal of the crankshaft is necessary.

Diesel Locomotives for Constructional Work

THE use of diesel-engined locomotives for contractors' and constructional works is widespread and is constantly increasing. To provide the most economical operation, the characteristics of the motive power, the wagons, and the excavator or other plant must be properly correlated. The following notes, taken from the *Demag News*, deal with some of the features of the locomotive design and construction.

* * * *

Nearly all buyers are of the opinion that locomotives are to be assessed solely by the horse-power. They do know that the tractive effort of a 50-h.p. steam locomotive must not be compared with that of a 50-h.p. diesel locomotive, but it is only in rare cases where it is appreciated that there are considerable differences also between diesel locomotives. It is just when comparing the tractive effort that one very often overlooks the fact that the load of the train has to be accelerated first by the locomotive and that considerable work has to be expended to this end. As soon as the locomotive is travelling with the train, the consumption of power is naturally less. It will therefore be found in the case of all diesel locomotives that they are not fully loaded when travelling, whereas, when starting, most of them even emit smoke.

Steam locomotives do not start so well under load as diesel locomotives. A steam engine has no revolutions prior to starting and consequently does not develop any horse-power. In most cases a steam locomotive does not develop its full horse-power until it is travelling at a speed of 10 to 15 km.p.h. When starting, the steam locomotive must produce the necessary torque by a large cylinder admission, and on the average steam locomotives, when starting, can develop a maximum torque equivalent to three times their full travelling output. With diesel locomotives the engine runs at the same number of revolutions and the gear transmission increases the torque at the rear axle when starting to three or four times the normal torque. When starting from rest, the conditions differ from those of a steam locomotive. With the first speed engaged, the diesel locomotive reaches a speed of about 4 km.p.h.—equivalent to an engine speed of, say, 1,000 r.p.m.—but the speed of the engine will be reduced enormously upon putting in the first speed before the locomotive starts, yet the torque remains always at the value corresponding to the speed of 4 km.p.h., even though the locomotive is moving more slowly at the commencement, because nearly half of the engine output is braked away by the friction clutch on starting, and is transformed into heat. The engine can develop a much greater torque if it has a fuel pump which, when the speed of the engine is slow and well below normal, gives it sufficient fuel to accelerate the initial load quickly, even though the exhaust may be smoky.

Acceleration in Relation to the Clutch

The accelerating power of a locomotive does not depend on the engine alone; the clutch, too, plays an important part. A clutch that does not grip gently enough and cannot absorb the friction work during acceleration consumes too much engine output. It may be said in principle that disc clutches grip more gently than cone clutches, and that clutches that are engaged by a screw nut or similar mechanical aids grip more gently than those engaged simply by the tension of a spring. This is the reason why acceleration is the poorest when employing cone clutches engaged by spring tension, and locomotives equipped with them will in most cases jolt on starting. Another important matter is the method of transmitting the power from the gear to the axles. The output surges quite a lot on starting. Power transmissions that are springy are apt to cause tension and, upon being released, do not restore the power peaks invested. These thus get lost, and the tractive effort of the locomotives is less by this amount. It is for this reason that locomotives with chain drive do not accelerate so well, and acceleration is at its worst when the driving chains do not act on the axles exactly horizontal but are inclined, because the spring suspension of the axle then works along with these power surges and consumes output.

Uniformity of Torque

With a view to ensuring good starting, it is important that the torque at the axle be uniform. The average torque that can be transmitted without the wheels slipping is fixed by the weight of the locomotive. The more uniformly this torque is transmitted to the axle the less likelihood there is of the wheels slipping. If peaks arise during the transmission of the torque they will not be transmitted, and only constitute a loss of output because there is then insufficient adhesion and the wheels slip. Toothed wheel and chain transmissions produce an absolutely constant torque. The worst is the jackshaft drive, which transmits the power to the axles by means of connecting rods, because then the wheels of the locomotive are driven alternately on the right and left sides with a variable torque.

It is essential for good acceleration that the locomotive has enough weight to prevent the wheels slipping; that the wheelbase is as large as possible, to prevent the locomotive swaying when starting, and jamming between the rails; and that well-centred buffers with well-sprung draw hooks are fitted. The adhesion weight generally assumed and realised for steam locomotives is 5 to 6 times the maximum tractive effort at the periphery of the wheel. In the case of diesel locomotives, this proportion may be much less, and is sometimes as low as 3·6 : 1.

The engines and gears of all diesel locomotives on the market have been perfected to such an extent that there is scarcely one construction that can be said to be bad. Nevertheless, there are types which, in regard to the transmission of the power to the axles, will not bear strong criticism. Advocates of chain transmission maintain that this drive is more elastic. This is true, but it is also the drive that squanders the output most. The reason for employing chain transmission is usually something else, namely price. Firms that export locomotives are unaware beforehand of the gauge for which the locomotive is to be supplied, so that they must construct their popular types with the wheels capable of being adjusted to comply with different gauges. The simplest and cheapest construction for variable gauges is that with chain transmission, because the drive and the sprockets can remain unaltered and only the track wheels require to be shifted. Other systems for variable gauges are a little more expensive, and are wider owing to the cranks being on the outside. But there is another drawback associated with chains, namely that of the chain stretching, which happens very often, with the result that it is then out of pitch. The sprockets get worn, the chains no longer mesh properly, and ultimately break. Toothed wheels transmit the torque to the axles just as uniformly as chains and have not the drawbacks of jumping and consuming an appreciable portion of the output.

Diesel Railway Traction

Another Big Argentine Order

A FURTHER important stage in the large-scale dieselisation of the railways in Argentina has been reached with the order for 10 triple-car trains and seven single-unit double-bogie railcars booked by Metropolitan Railcars (Ganz Patents) Ltd. The purchase of these vehicles by the Argentine State Railways at a contract price of £293,517, (payable by instalments), has been sanctioned by the Ministry of Public Works. Both three-car trains and single cars are to be built throughout at the Budapest works of Ganz & Co. Ltd., which company is now represented in Argentina by Metropolitan Railcars (Ganz Patents) Ltd. All the stock is for metre-gauge lines, and the three-car trains, with a 240-b.h.p. engine and transmission set at each end, are to be similar in design to the Ganz sets now operating on the Catamarca section of the State Railways, but modernised in various respects, particularly as regards the installation of a complete air-conditioning equipment of twice the capacity of existing sets, and the adoption of further means to prevent the entrance of dust into the passenger saloons. The State Railways administration felt that the need for new diesel railcars and trains was urgent, in order that working expenses might be reduced to the lowest possible level coincident with the provision of facilities for increasing the traffic, which joint result past experience had proved was a characteristic of diesel vehicles. In order to obtain quick delivery, and maintain that uniformity of construction and equipment which is so advantageous in maintaining and operating any type of motive power, the Ganz type of train was chosen. For these reasons, and because of the favourable purchase price of the earlier Ganz vehicles on the State lines, the contract was signed without calling for public tenders. When this order is completed the whole 143 diesel vehicles of the Argentine State Railways will be of Ganz make, covering 5 ft. 6 in. 4 ft. 8½ in., and metre-gauge lines.

American Streamliner Accident

ON August 12 the 17-car 6,300 b.h.p. diesel-electric streamliner *City of San Francisco* was derailed when running at speed over Southern Pacific tracks in the Humboldt River canyon in the eastern part of Nevada. More than 20 of the 150 passengers were killed, and nearly 100 injured. Deliberate displacement of a rail is said to have been the cause of the disaster, and the coroner's jury returned a verdict to that effect next day, while bodies were still being recovered from the wreckage. All but two of the 14 passenger cars left the track and the two rear units of the three-section locomotive were derailed. The leading power unit did not leave the rails and crossed safely over a narrow bridge after passing the displaced rail, covering about 1,000 ft. before the train came to rest. Five cars in the centre of the train broke through the steel girders of the bridge and fell into the river. No passenger in the last five cars of the formation was killed. Six of the 14 passenger cars are said to have been damaged beyond repair by the accident itself and by the amount of flame cutting which had to be done to extricate passengers. The *City of San Francisco* is one of two 17-car trains built in 1937 for service between Chicago and California, and is operated jointly by the Chicago & North Western, Union Pacific, and Southern Pacific Railroads on a 39¾-hr. schedule over the 2,263 miles between Chicago and Oakland. It measures 1,290 ft. long overall and cost nearly $2,000,000; the weight of the trailing load is 732 English tons empty and 765 tons full, and the three-section locomotive weighs 392 tons. Illustrations of the train wreckage after the smash will be found on page 145 of this Supplement. The heavily-stressed members of the bodies and underframes are of steel, but a certain amount of aluminium alloy has been used, and the three power cars are entirely of steel, with the Pullman Company's special bull-nosed front incorporating the radiator grille.

Making the Diesel Flameproof

ONE of the most curious things about diesel locomotives for special industrial duties is the lengths to which some people will go in order to prevent the flying of sparks from spots where the only possible sparks would be of such low temperature and of such brief duration that there would be little danger if the locomotive was operating in gaseous gunpowder. We refer, of course, to the coverings put on buffer heads, coupling chains, and the like. If a diesel locomotive is to be made sufficiently flameproof to work in a gassy mine or explosive area, a little more imagination is required. Without a great deal of trouble or expense it is possible to prevent flames from the oil engine cylinders coming out through the exhaust or being blown back through the engine air intake, and such simple precautions are most necessary, for fatal explosions have been known to occur from such a cause. Even so, the locomotive is then flameproof only in fairly ordinary atmosphere, and the requirements for an explosives factory or a gassy mine are much more severe, for although combustion flame from the cylinders may be prevented from passing out through the exhaust-gas conditioner or back *via* the air intake, it is possible for flame to form in either the exhaust manifold or the air intake duct, and if the atmosphere in those ducts happens to be explosive, flame could easily be forced out through the exhaust conditioner or the air filter, if, indeed, the resulting explosion did not wreck the pipe itself. If such conditions are to be met it means that in addition to special exhaust conditioners, appreciable modifications must be made to the engine cylinders, cylinder heads, valve gear casings, and manifold joints. The equipment as a whole should be able to pass the tests for flameproof electrical equipment in mine service, as is specified, for example, in the Hunslet flameproof diesel locomotives for surface and sub-surface operation in dangerous atmospheres. Unless some such precautions are taken it is a waste of time and money, and not particularly sound engineering, to cover the buffer heads in horse-hair, plush, or soft frictional material.

XUM

THE TRACTION GEARBOX AND ITS CONTROL

A well-tried construction which seeks to eliminate the disadvantages of the normal mechanical transmission systems, and which is used in conjunction with a fluid coupling and Tele-change preselective control

ONE of the principal ways in which inventors have sought to improve the design and operation of mechanical transmissions for diesel locomotives and railcars within the last few years has been to eliminate the break in tractive effort during the change from one step to another. A further avenue of possible improvement is in the elimination of frictional drive through clutches, for although several successful boxes with individual clutches for each step are in service, there is still a liability to shock during gear changes, and also to wear.

It was in an endeavour to overcome these difficulties and at the same time provide a light preselective control, that the Traction gearbox was evolved some years ago by the Hydraulic Coupling & Engineering Co. Ltd., for use direct coupled to the Vulcan-Sinclair fluid coupling. This type of gearbox with Tele-change preselective control has been applied to several diesel shunting locomotives engaged in arduous service, and has proved that a quick and easy gear-change can be made with comparatively little drop in tractive effort, and without any maintenance difficulties.

The pioneer work has been carried out by Hudswell, Clarke & Co. Ltd., of Leeds, who were the first locomotive firm to use the Vulcan-Sinclair fluid coupling, and the Traction gearboxes have been constructed to that maker's order by Bostock & Bramley Limited.

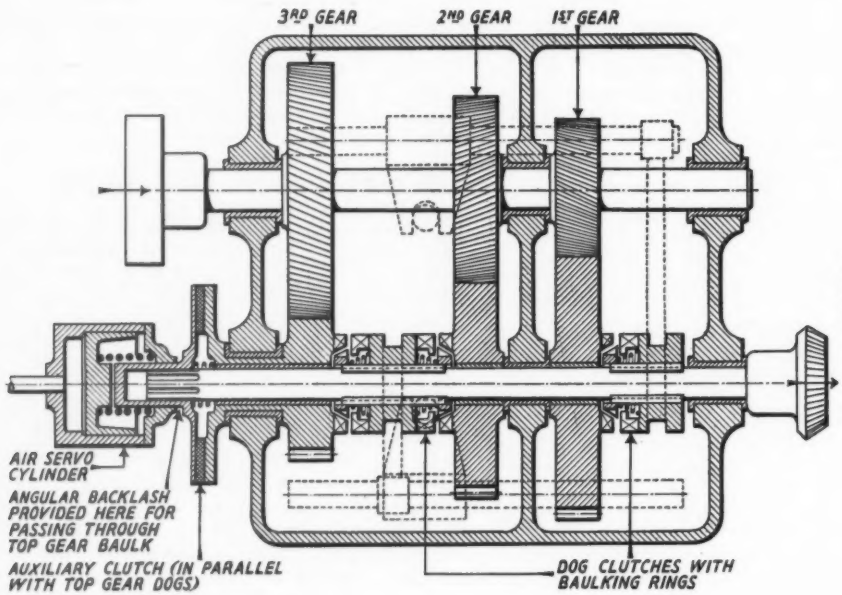

3RD GEAR
2ND GEAR
1ST GEAR
AIR SERVO CYLINDER
ANGULAR BACKLASH PROVIDED HERE FOR PASSING THROUGH TOP GEAR BAULK
AUXILIARY CLUTCH (IN PARALLEL WITH TOP GEAR DOGS)
DOG CLUTCHES WITH BAULKING RINGS

Fig. 1—Section through a three-speed Traction gearbox with constant-mesh gears and dog-clutch engagement

Gearbox

Fundamentally the Traction gearbox is of the simple layshaft type with constant-mesh gears and dog-clutch engagement, suitable, as the name implies, for direct connection to a Vulcan-Sinclair traction-type fluid coupling; there is no friction clutch in the main drive. The principal features of the design are the provision of an auxiliary friction clutch in parallel with the top-gear dog-clutch for use only when changing-up, and the use of baulking rings. The use of the auxiliary clutch shortens the time of gear-change and maintains traction on the vehicle while the main drive is being changed by the dog clutch. The baulking rings are used so that the gear-change is effected only at synchronism, whether the gear is being changed up or down; thus clashing of gears is impossible. As the dog clutches are actuated through spring-link or other resilient means the control can be made preselective. The actual change is effected by closing the throttle and engaging the auxiliary clutch when changing up; and by closing and then reopening the throttle when changing down.

In Fig. 1 is shown the Traction-type gearbox. It is used in conjunction with the Vulcan-Sinclair traction-type fluid coupling with idling drag eliminator. The drag brake is applied when the engine is idling in order to stop rotation of the gearbox shafts, and turn them slowly backwards as a means of engaging forward or reverse, which, in the accompanying drawings, is shown with the conventional double-bevel gear.

Gear-changing is effected by a pneumatic operating cylinder mounted on top of the gearbox and acting on the pivoted lever shown. When compressed air is admitted, the gear is shifted into neutral, and the return motion by means of a spring engages the gear which has been preselected—the actual meshing of the dogs being controlled by the baulking ring to occur only upon synchronism. The gear-selecting lever is provided with a latch controlling a small valve which applies air pressure to a relay cylinder actuating the control valve admitting air to the gear-change operating cylinder. The exhaust from the relay cylinder is controlled by a trip valve which is

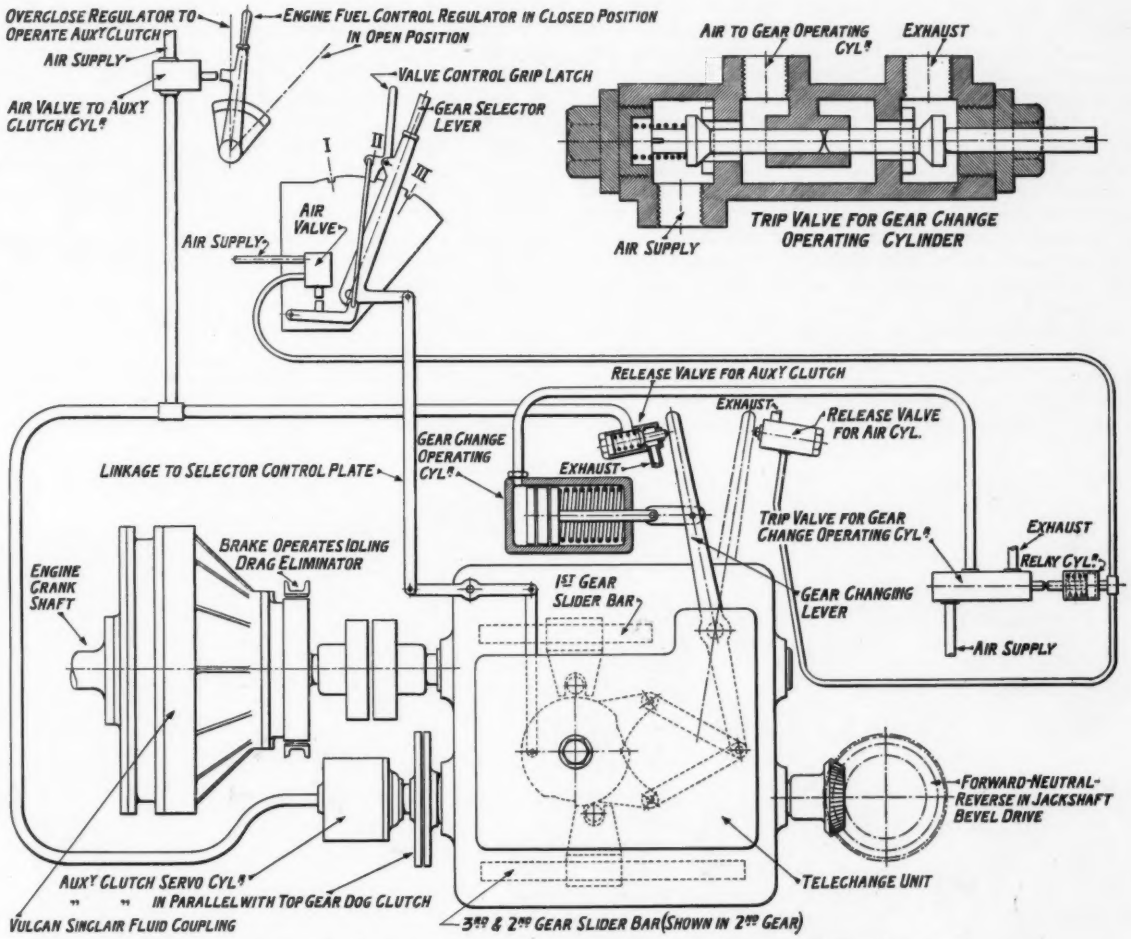


Fig. 2—Compressed air control arrangement for the operation of the Traction gearbox

operated by the gear-changing lever, when the neutral gear position is reached. (Lever shown dotted.)

The engine fuel control regulator is shown in the top right-hand corner of Fig. 2, and it is arranged to open a valve admitting air to engage the auxiliary clutch when changing up. This is done by " over-closing " the regulator and thus engaging the auxiliary clutch when the power of the engine is cut off. Immediately the gear-change is completed under the control of the baulking ring, the air is released from the auxiliary clutch cylinder by means of a second trip valve operated from the gear-changing lever upon its return travel from neutral. That is to say, as soon as the dog clutch passes through the baulk this release valve is tripped by the return motion of the gear-change lever and the air is immediately exhausted, thus releasing the auxiliary clutch as soon as the change of gear has taken place.

Driving Operations

Assume the engine to be idling with the forward and reverse gears in neutral and the locomotive stationary, remembering that there is no neutral position within the gearbox, only a transitional neutral when changing gear. The driver will select, say, forward gear, and use a latch-operated valve on the forward and reverse lever to admit air to the drag eliminator brake cylinder. This stops rotation of the gear shafts and turns them slowly backward so that the forward-gear dog clutch is easily meshed, whereupon the drag brake is released and the idling torque is transmitted to the driving wheels. Normally, the gear-selecting lever would have been put into the low gear position and the action of the drag eliminator in reversing the rotation of the gearshafts would permit the low-gear dog clutch to pass through the baulking ring and engage under the action of the return spring. The driver then opens up the regulator and the fluid coupling transmits the power to accelerate the locomotive with its load—there being no shock, since the driving connection has been established by engaging the forward dog clutch with the parts practically stationary.

To change to second gear, the driver leaves the engine regulator open and moves the gear-selecting lever to position II. He must operate the grip latch to do so, and thus admit compressed air to the small relay valve which puts the piston in the gear-change operating cylinder under pressure. Since the first-gear dogs are loaded, however, the gear does not shift into neutral until a moment later, when the regulator is closed to the limit (*i.e.* overclosed), thus admitting air to the auxiliary clutch cylinder. The low-gear dogs immediately disengage due to the reversal of torque, and the compressed air in the operating cylinder moves the piston to the limit of its travel, thus putting the gearbox into neutral, and at the same moment opening the trip valve which exhausts the small relay cylinder and thus puts the operating cylinder in communication with atmosphere. The compressed spring immediately returns the gear-change lever to the left and the second gear slider bar is

engaged by the Tele-change mechanism, being slid to the right until the dog clutch comes against the baulking ring.

Meanwhile, the speed of the engine is being rapidly pulled down by the engagement of the auxiliary clutch, and at the moment of synchronism the second-gear dog passes through the baulking ring and engages; at the same instant, the gear-change lever trips the release valve to exhaust the air from the auxiliary clutch cylinder. The driver hears the exhaust and immediately opens the regulator to transmit power in second gear, the actual time of the gear-change being only about one second. Tractive effort is maintained during the change by the auxiliary clutch, which makes use of part of the flywheel energy of the engine and hydraulic coupling, so that the locomotive keeps under way without slackening of the drawbar couplings.

The change to third gear is effected in the same way by setting the control lever to position III and then over-

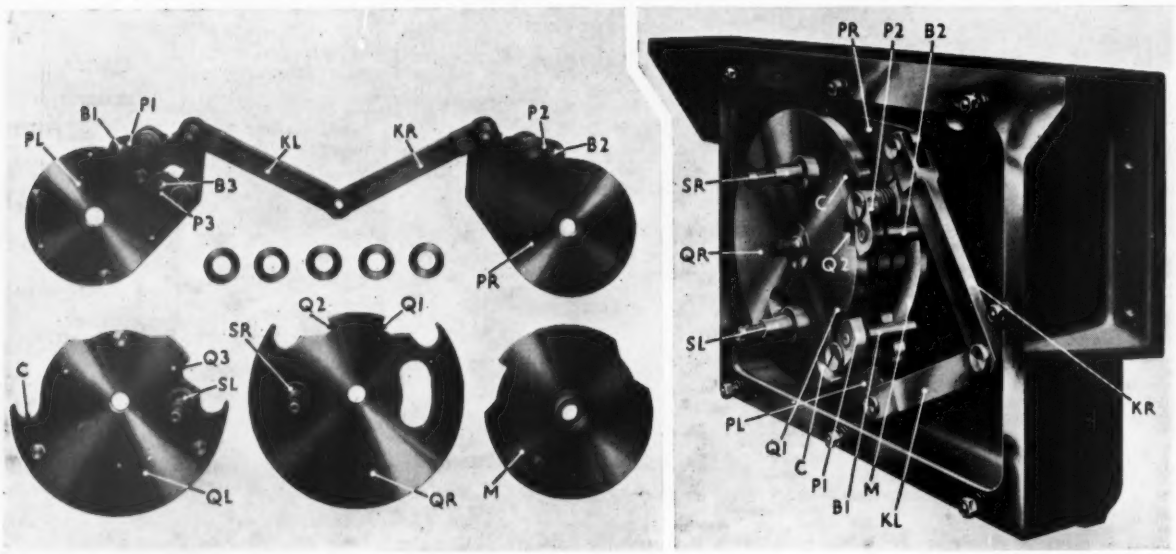


Fig. 3—Constituents (dismantled) of ratchet and pawl mechanism of Tele-change control

closing the regulator so as to cut off the power of the engine and engage the auxiliary clutch, so that the second gear is disengaged by the operating cylinder in the outward travel of the piston and the third gear is engaged under the control of the baulking ring at synchronism by the return travel of the piston.

When changing from second to third gear, the third-gear dog clutch rests on the baulk while the auxiliary clutch brings the engine speed down to synchronism. It is actually necessary for the engine speed to drop a tiny fraction below synchronism to allow the dog clutch to pass through the baulk, and this is provided for in practice by the simple expedient of allowing a small amount of angular lost motion, say, 20° or so, in the drive through the auxiliary clutch. Thus the latter pulls the engine speed down to synchronism and this small angular lost motion permits the further fractional drop in speed to allow the dog clutch to pass through the gate in the baulking ring.

The sequence when changing down is similar, except that the driver does not over-close the regulator and, therefore, does not bring the auxiliary clutch into action. For example, on changing down to second gear, the driver moves the control lever to the second-gear position, thus admitting compressed air to the gear-change operating cylinder, but the top-gear dogs are torque-loaded and cannot disengage. To effect the gear-change the driver momentarily closes the regulator and immediately re-opens it. The reversal of torque allows the top-gear dogs to be disengaged by the operating cylinder, which makes a full stroke to the right, operating its trip valve so that the spring return engages the second gear through the Tele-change mechanism under the control of the baulking ring. In the meantime, the engine is accelerating because the regulator was only momentarily closed, and at the instant of synchronisation the second-gear dogs engage silently, taking up the drive in that gear.

The sequence when changing down to first gear is the same, the change being effected by momentarily closing and re-opening the regulator. The only difference between changing up and changing down is the natural difference that when changing up there is a pause of brief duration during which the driver holds the regulator in the over-closed position. Immediately the gear-change is effected he hears the exhaust from the trip valve of the auxiliary clutch cylinder and re-opens the regulator.

If the vehicle were stopped in top gear and had to re-start in low gear in the opposite direction, the driver would first move the gear control to the first gear notch. This admits compressed air to the gear-change cylinder, which puts third gear into neutral, and upon the return travel picks up the first-gear dog clutch which comes up against the baulk. Then the driver operates the forward-and-reverse control lever, admitting air by the latch valve to the drag eliminator brake, which completely removes the drag torque on the forward dog clutch, permitting the lever to be moved across into the reverse position and engaging the reverse-drive dog clutch. Due to the reversal of rotation of the gear-shafts, the first-gear dog clutch passes through the baulking ring into full engagement, so that the locomotive can be driven in the selected direction.

Tele-change Control

The object of this system, adopted by the Hydraulic Coupling and Engineering Co. Ltd. to the design of Mr. R. C. Clerk, is to provide a light preselective remote control for the Traction gearbox and any other form of synchronised sliding-engagement gearbox. The actual

changing and engaging of the gears is effected by a single servo cylinder in accordance with the control setting.

In principle, a connection from the gear-change cylinder is pivoted to a rotating disc carrying a pawl. When the disc is rotated in one direction the pawl engages with a ratchet plate pivoted about the same centre as the disc. The ratchet plate turns when engaged by the pawl, and a lever extending from it causes the gearbox selector rod to slide, and so engage the selected gear under control of the baulking device. Another disc (termed a masking plate) with separate rotating mechanism operated by the gear preselecting lever, is added to the assembly; a pin projecting from the pawl rests on the edge of this masking disc, so that the pawl is held up clear of the ratchet plate. A notch is cut in the edge of the masking plate so that the pawl pin can move into it and permit the pawl to engage with the ratchet, and thus move the gearbox selector rod, at the will of the driver. It is the light hand-lever operation which preselects the Q_2, and Q_3 on the ratchet plates QL and QR which operate the gearbox striking forks through the lugs SL and SR. These ratchet plates also have curved recesses C with which the back ends of the pawls may co-operate during the first part of the working stroke, so as to shift the gear previously engaged back to neutral.

Built into the pawls parallel to the pivot axis are the pawl baulk pins B_1, B_2, and B_3, which can bear against the circular masking plate M so as to withhold the pawls from engagement with the ratchet faces except when a notch in the edge of the mask allows a particular pawl to mate with its appropriate ratchet face during the second or engaging part of the working stroke, following which the ratchet plate is angularly displaced in correspondence with the pawl-carrying plate so as to strike the gear required.

The latch on the manual control lever is connected to the servo valve so that the gear-change operating cylinder is energised before the lever can be moved in its gate.

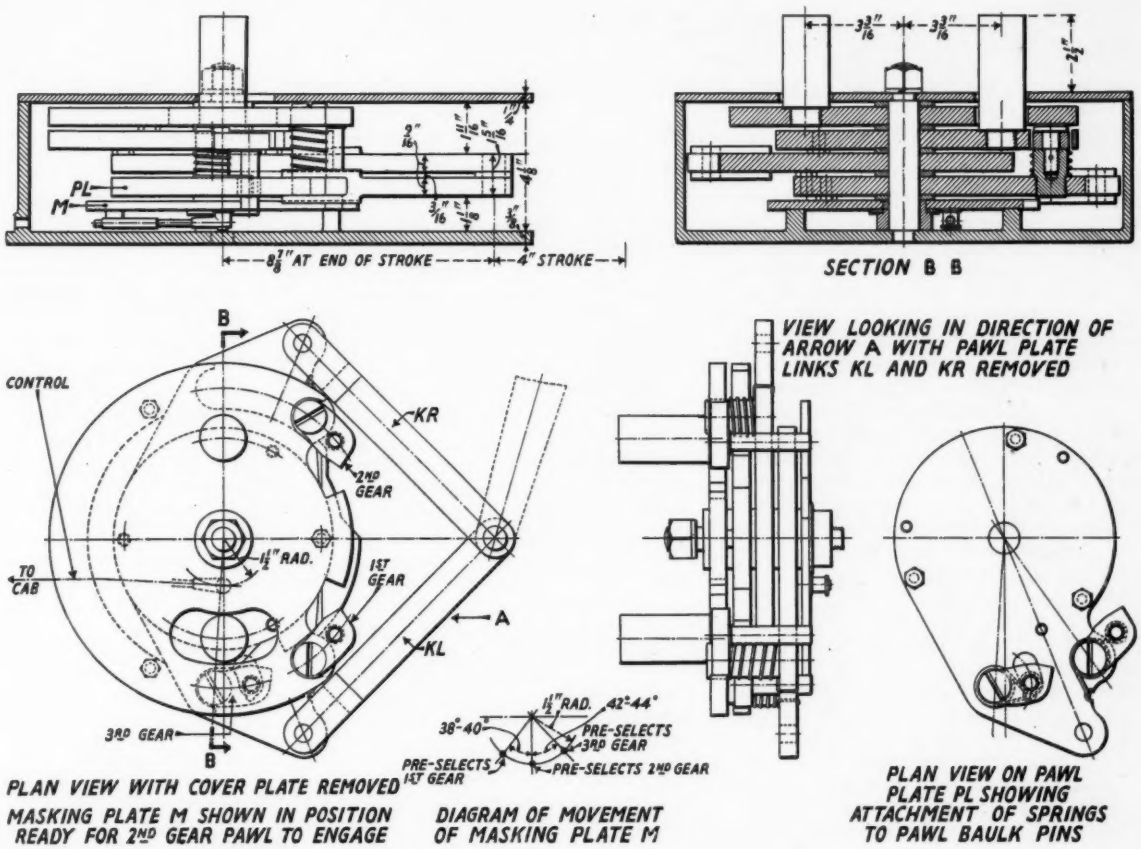


Fig. 4—Details of the pawl and ratchet mechanism of Telechange control as applied to a three-speed Traction gearbox

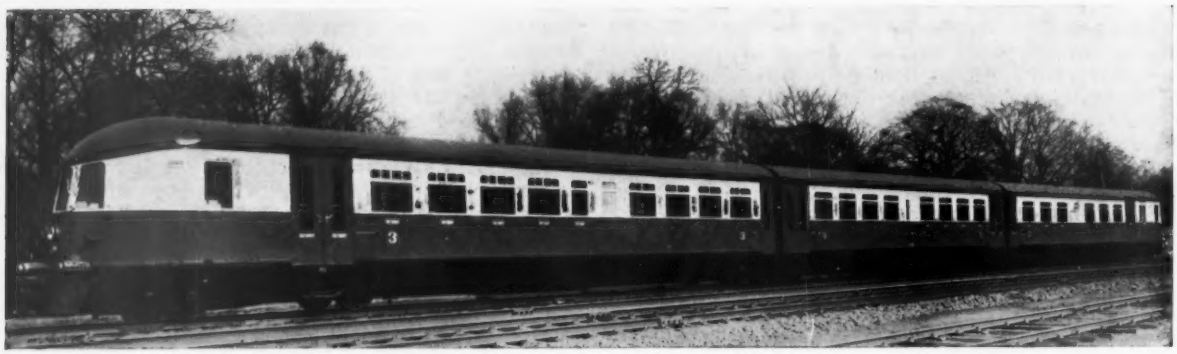
gear, but the actual engagement of the gears is carried out by the spring-actuated return motion of the gear-change cylinder.

Regarding the actual mechanism (Figs. 3 and 4) the servo actuating lever is connected by a pair of splayed links KL and KR to left-handed and right-handed pawl plates PL and PR, so that these rotate in opposite directions when actuated by the servo. Mounted on standards on these pawl plates are pawls P_1, P_2, and P_3, sprung inwards, so that they may engage with ratchet faces Q_1, The first movement of the servo piston causes the pawls to move backwards in a manner such that the back end of the pawl in use engages the curved recess in the ratchet plate. Also, the underside of the pawls is specially shaped to work up the back slope of the ratchet, which has the effect of lifting the pawl baulk pin clear of the masking plate, which can then be rotated freely to another position by the movement of the control lever, the actual change of gear being deferred until allowed by alternation of the driving torque when the engine throttle is closed.

XUM

DIESEL TRACTION ON THE BELGIAN NATIONAL RAILWAYS

An account of the development, operation, and working costs of railcars and multi-unit trains, and descriptions of the important orders completed during the past two months



Triple-car 730 b.h.p. diesel-electric train built in 1936 for express service on the Belgian National Railways

BEGINNING in 1930 with three 150 b.h.p. double-bogie railcars with Maybach diesel engines and Maybach mechanical transmission, the Belgian National Railways increased their stock in 1932 by a 200 b.h.p. diesel-electric railcar, and in 1933 introduced 14 railcars to a design based on that of the 1930 vehicles, but brought completely up-to-date and embodying a Maybach engine of 175 b.h.p. All these cars were for local passenger traffic, and in 1934 a further extension of such services was made with the delivery of five four-wheel Ganz cars, a 140 b.h.p. four-wheel car with an M.A.N. engine, and two 30-ton bogie cars each with a 210 b.h.p. Maybach engine. At the same time a twin-articulated train with one 410 b.h.p. Maybach engine was introduced in fast service between Brussels and Ghent. A little later, a bogie car was delivered for local traffic, and was powered by a 220 b.h.p. Carels-Ganz engine and equipped with mechanical transmission.

Early in 1935 orders were placed for three double-bogie railcars to different designs, and for eight triple-car articulated diesel-electric express trains to four different designs. All of these were delivered in 1936. Particulars of these early Belgian railcars and trains and their operations will be found in the issues of this Supplement for May 18, 1934, and March 22, 1935. The working of this stud, taken *in toto*, has indicated that railcars can show a working cost only 59 to 60 per cent. that of corresponding steam trains in local service, and based on mileage.

Present Programme

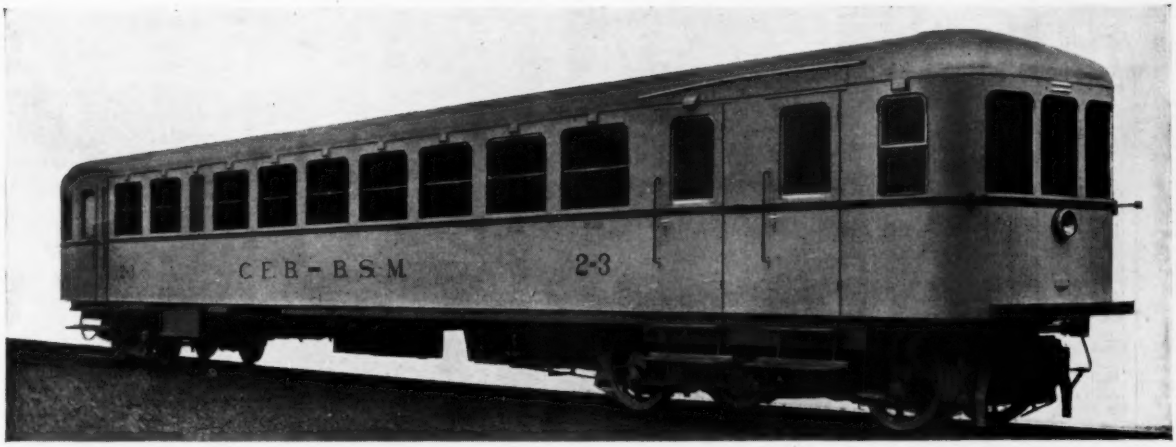
Railcar operating experience over a period longer than seven years, and the necessity of greatly reducing the operating costs of local services and fast interurban business trains, led to a new construction programme being initiated early in 1938, when orders were placed for six 370 b.h.p. double-bogie railcars, 12 twin-car articulated trains, and six triple-car non-articulated formations. The single-unit cars have Carels-Ganz engines and mechanical transmission; the twin-car sets have two power plants, each similar to that of the single-unit cars; and the triple-car sets have each two Maybach pressure-charged engines of 600 b.h.p. and Voith hydraulic transmission. Subsequently it was decided to make an intensive effort to reduce branch-line costs, and six four-wheel and six double-bogie light-weight cars of Brossel manufacture were ordered, and later a contract for the delivery of another 50 four-wheelers of the same make was signed. Of these 1938-39 orders, all the triple-car and twin-car sets are delivered, delivery of the six big single-unit cars is almost complete, the six light bogie and the first six four-wheel Brossel cars are in traffic, and the last 50 are under construction.

Experience and Modifications

Up to and including the vehicles of the 1936 programme, electric transmission was used for all cars or trains with an individual engine capacity exceeding 330 b.h.p., but with the programme now being completed a big change-over has been made, mechanical transmission being used for engine outputs up to 370 b.h.p. and the turbo type of hydraulic transmission for the 600 b.h.p. engines. In all the cars and trains with 370 b.h.p. engines an English fluid coupling has been incorporated in the transmission, but in the Brossel cars, both four-wheel and eight-wheel, the transmission is much the same as in a heavy lorry.

Experiences with some of the cars and trains of the 1936 delivery have not been too happy, and the Frichs

One of the original 150 b.h.p. Maybach-engined cars in Belgium, operating on local service



One of 14 railcars built in 1934 by La Brugeoise, and fitted with a 175 b.h.p. Maybach engine

and Mercédès engines gave some trouble. Accordingly, the three-car train with a 400 b.h.p. Frichs engine at each end has been converted into a two-car set powered by only one 400 b.h.p. engine, and used in slower traffic; the second engine is held as a spare. Neither the 330 nor the 450 b.h.p. Mercédès engines gave what was considered satisfactory service. The 330 b.h.p. engine of this make from the railcar of Type 607 has been scrapped and replaced by one of the 450 b.h.p. engines from the triple-car train of Type 655, and derated to give a lower maximum output; the second 450 b.h.p. engine from the train, similarly derated, is used as a spare, and the triple-car train itself is now driven by two Maybach 410 b.h.p. engines.

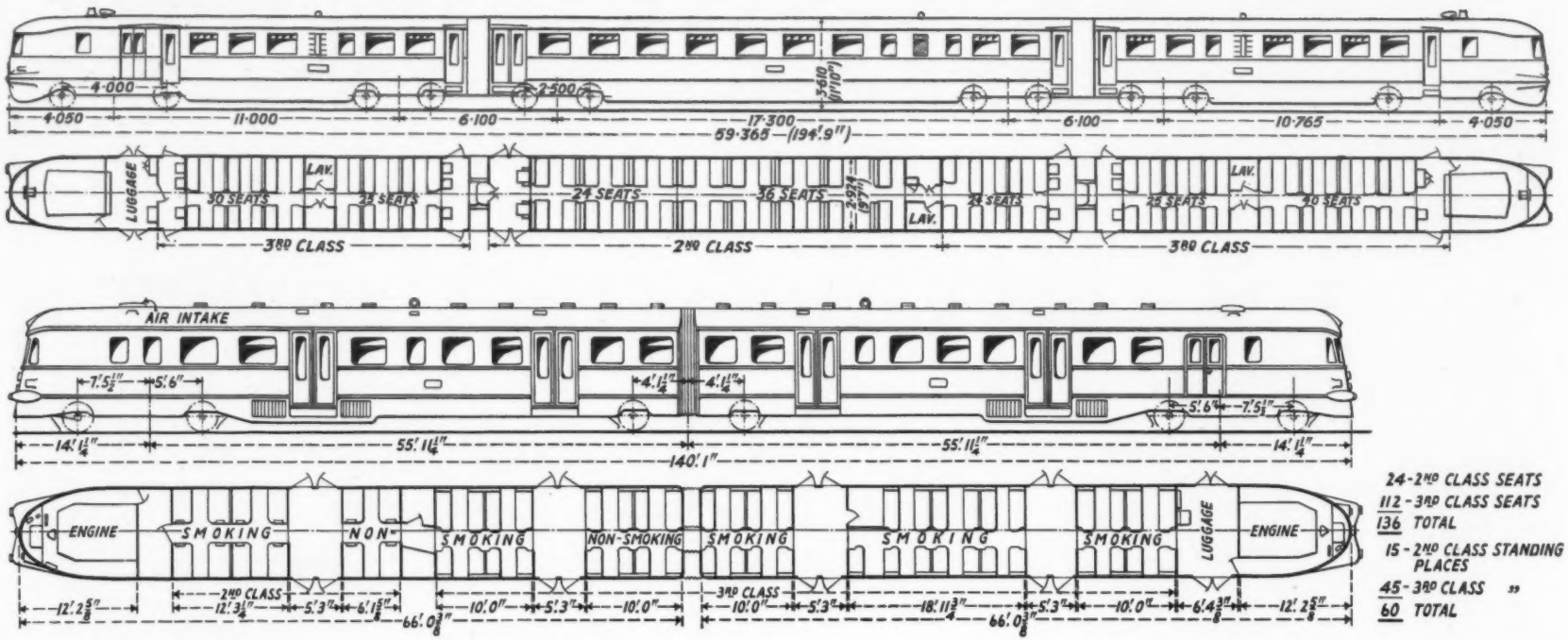
The design of the 1939 twin-car and triple-car sets shows considerable detail changes from that of the 1936 stock. Some trouble was experienced with axle breakages, and by making each vehicle separate instead of articulated, the new triples have a maximum axle-load of 16 tons compared with 20 tons in the trains set to work in 1936, and owing to the substitution of hydraulic for electric transmission, and thus the elimination of nose-suspended traction motors, the unspringborne weight on each axle is considerably less. Changes have also been made in the bogie frames, spring suspension and wheels. Multiple-unit control is not fitted to any of the 1939 railcars or trains.

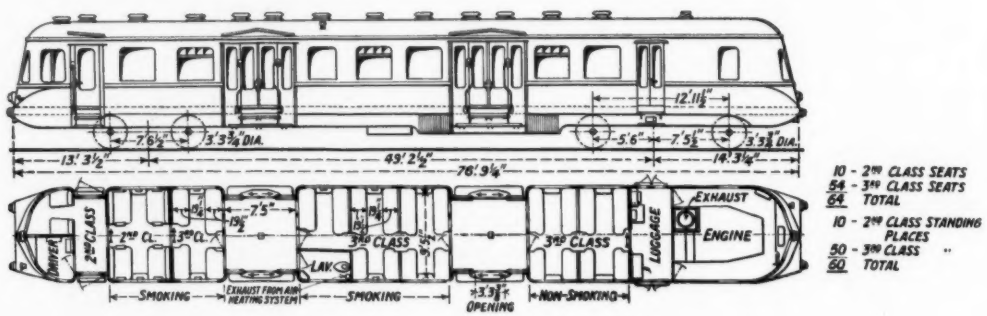
On the accompanying map are shown the lines of the Belgian National Railways which now have diesel railcar services, but a considerable increase in the route mileage operated over by railcars will be effected when the 50 Brossel units are delivered. Taking into account the

DIESEL RAILCARS AND RAILCAR-TRAINS, BELGIAN NATIONAL RAILWAYS

Year placed in service	No. of railcars or trains	Type	Arrangement of vehicle	Class No.	Railcar Constructors			No. of engines and power of each	Capacity		Tare weight, tonnes	Gross weight, tonnes	Max. speed, km.p.h.
					Mechanical portion	Engine	Transmission		Seats	Standing			
1930	3	Diesel-mech.	Bogie car ..	600	E.V.A. ..	Maybach ..	Maybach ..	1 × 150*	92	80	39·3	54·1	65
1932	1	Diesel-elect.	Bogie car ..	650	D.E.V.A. ..	Burmeister & Wain	A.S.E.A.	1 × 200	80	50	43·0	54·1	80
1933	14	Diesel-mech.	Bogie car ..	601	La Brugeoise..	Maybach ..	Maybach	1 × 175	104	50	32·6	46·0	85
1934	1	Diesel-mech.	Bogie car ..	602	La Brugeoise..	Maybach ..	Maybach	1 × 210	100	50	30·3	43·4	85
,,	1	Diesel-elect.	Bogie car ..	651	La Brugeoise..	Maybach ..	A.C.E.C.	1 × 210	100	50	31·2	44·3	90
,,	1	Diesel-elect.	Twin-car artic. ..	652	La Brugeoise..	Maybach ..	Siemens-A.C.E.C.	1 × 410	185	30	67·5	87·2	150
,,	1	Diesel-mech.	2-axle car ..	603	La Dyle ..	M.A.N. ..	T.A.G.	1 × 140	57	18	16·0	22·8	80
,,	5	Diesel-mech.	2-axle car ..	604	Ganz	Ganz ..	Ganz	1 × 120	60	20	15·2	22·1	70
1935	1	Diesel-mech.	Bogie car ..	605	Braine-le-Comte	Carels-Ganz	Ganz	1 × 220	100	50	29·0	41·9	82
1936	1	Diesel-mech.	Bogie car ..	606	Baume-Marpent	Carels-Ganz	S.L.M.	1 × 320	70	60	36·6	48·7	85
,,	1	Diesel-mech.	Bogie car ..	607	Haine-St. Pierre	Mercédès ..	S.L.M.	1 × 330‡	70	60	35·0	46·7	88
,,	3	Diesel-elect.	Triple-car artic.	653	La Brugeoise..	Maybach ..	A.C.E.C.	2 × 410	229	40	126·4	151·9	150
,,	3	Diesel-elect.	Triple-car artic.	654	Baume-Marpent	Carels-Ganz	S.E.M.	2 × 365	229	40	133·0	159·5	135
,,	1	Diesel-elect.	Triple-car artic.	655	Baume-Marpent	Mercédès ..	A.C.E.C.	2 × 450§	229	40	130·0	156·5	150
,,	1	Diesel-elect.	Triple-car artic.‖	656	Baume-Marpent	Frichs ..	A.C.E.C.	2 × 400‖	229	40	132·0	158·5	140
1939	6	Diesel-hydraulic	Triple-car non-artic.	(?)	La Brugeoise..	Maybach ..	Voith	2 × 600†	219	25	134·7	159·0	160
,,	12	Diesel-mech.	Twin-car artic...	(?)	Baume-Marpent	Carels-Ganz	S.L.M.	2 × 370	136	60	96	109	130
,,	6	Diesel-mech.	Bogie car ..	(?)	Baume-Marpent	Carels-Ganz	S.L.M.	1 × 370	64	60	45	53	130
,,	6	Diesel-mech.	Bogie car ..	(?)	Brossel ..	Brossel ..	Brossel	1 × 140	80	40	24	34	60
,,	6	Diesel-mech.	2-axle car ..	(?)	Brossel ..	Brossel ..	Brossel	1 × 140	50	30	15	20	60
U.C.	50	Diesel-mech.	2-axle car ..	(?)	S.N.C.F.B. ..	Brossel ..	Brossel	1 × 140	50	30	15	20	60

* Now 175 b.h.p. † Pressure-charged. ‡ Now replaced by ex-450-b.h.p. engine derated. § Now replaced by two 410 b.h.p. Maybach engines.
‖ Now a twin-car train with one Frichs 400 b.h.p. engine.



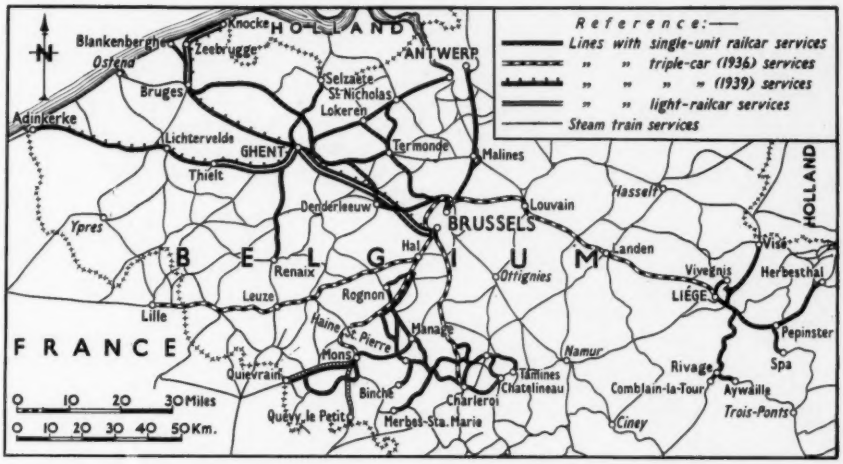


NEW EXPRESS AND SEMI-EXPRESS DIESEL TRAINS AND RAILCARS SET TO WORK WITHIN RECENT WEEKS ON THE BELGIAN NATIONAL RAILWAYS

Top : Triple-car 1,200 b.h.p. diesel-hydraulic train for fast interurban trains. Maximum service speed, 100 m.p.h.

Centre : Twin-car 740 b.h.p. diesel-mechanical train for fast interurban or accelerated stopping services. Maximum service speed, 80 m.p.h.

Bottom : Double-bogie 370 b.h.p. diesel-mechanical railcar for semi-express services. Neither this nor the triple-car nor twin-car trains are fitted with multiple-unit control



Map showing the lines of the Belgian National Railways over which diesel railcar or railcar-train services were in operation in August, 1939. An increase in the railcar mileage will take place when 50 local railcars now on order are put into traffic

modifications made to two of the 1936 diesel trains, the Belgian National Railways now have in traffic 12 four-wheel cars, 35 double-bogie cars, 14 twin-car trains, and 13 triple-car trains, and another 50 four-wheel cars are being built.

New Triple-Car Trains

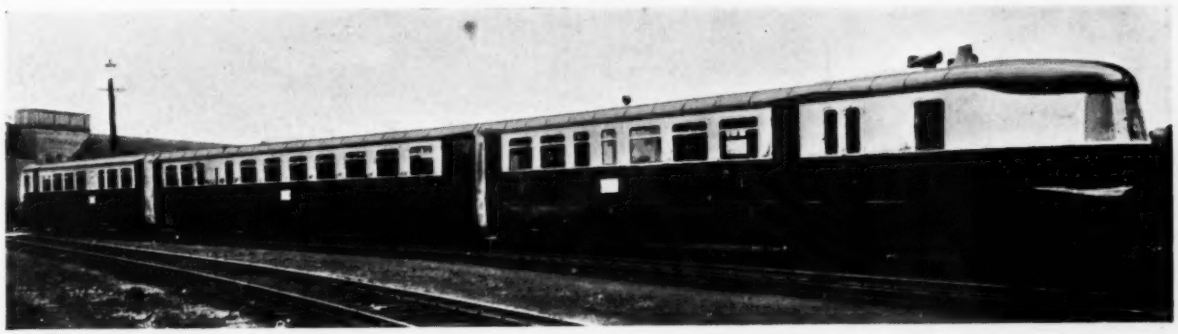
Each of the six new three-car formations is powered by two Maybach 12-cylinder vee engines pressure-charged on the Büchi system to give an output of 600 b.h.p. each at 1,400 r.p.m., and driving through a Voith triple-converter hydraulic transmission giving three combinations up to the top speed of 160 km.p.h. (100 m.p.h.). Within an overall body length of 59·365 m. (195 ft.) there are 62 second class and 157 third class seats, and the weight with a full complement of passengers and luggage is 159 *tonnes*. The tare is 134·75 *tonnes* and the weight with supplies but without passengers is 139 *tonnes*. The main contractor and builder of the mechanical portion was the S.A. La Brugeoise et Nicaise & Delcuve.

All the motive power is carried on the two end bogies of the train, so that all the others are of the carrying type. One of the end cars has a baggage space, but apart from this and the engine rooms the floor space in these two vehicles is given up to third class seats. The centre trailer is longer than the end power cars, and has second and third class seats as well as a compartment for the oil-fired train-heating boiler. The skirt of the generally streamlined contour is lifted a little at the bogies to facilitate examination of the axleboxes, brake gear and spring rigging.

The driving bogies are of the Görlitz type slightly modified, and the trailing bogies are to a design based on that of the so-called Pennsylvania bogies of the new all-steel carriages of the S.N.C.F.B. The driving bogie structure is built up of steel plates and pressings electrically-welded together, and formed to secure great torsional and lateral rigidity, features which experience with the earlier trains had shown to be most necessary for the sake of safety and of lighter maintenance. The suspension comprises at each side a long inverted laminated spring with great camber, which supports the body and cushions its movements, and a light overhung laminated spring with helical auxiliaries at each axlebox. The axleboxes are of the S.K.F. roller-bearing pattern, and are outside the wheels. The axles are of nickel-chrome steel and the tyres of chrome-molybdenum steel. Separate mounting is used for the engine and hydraulic torque converter; the former is bolted to a welded steel subframe supported on the bogie frame structure at three points; the converter unit is carried by cylindrical bearings at three points directly on the bogie frame structure.

A monobloc steel casting is used to form the frame structure of each carrying bogie, and as many details as possible are to existing Belgian National standards for all-steel passenger rolling stock, but the suspension and braking systems have been designed particularly for these diesel trains. The axleboxes are on the Isothermos principle.

Westinghouse air brakes are incorporated, and the equipment comprises a quick-acting system with a centrifugal retardation controller, giving a maximum braking pressure of 160 per cent. at all speeds down to 80 km.p.h. (50 m.p.h.), and then a gradual decrease to 80 per cent. just before stopping. With moderate brake applications the retarding force varies in the same fashion; for example, an initial braking force of 80 per cent. above 80 km.p.h. (50 m.p.h.) would be reduced to 40 per cent.



One of the six new 1,200 b.h.p. triple-car diesel-hydraulic trains for a top speed of 100 m.p.h.

XUM

Interior of second class saloon in the latest triple-car express diesel-hydraulic trains in Belgium. The ventilating air is filtered, and in cold weather is preheated in a heat exchanger below the car floor

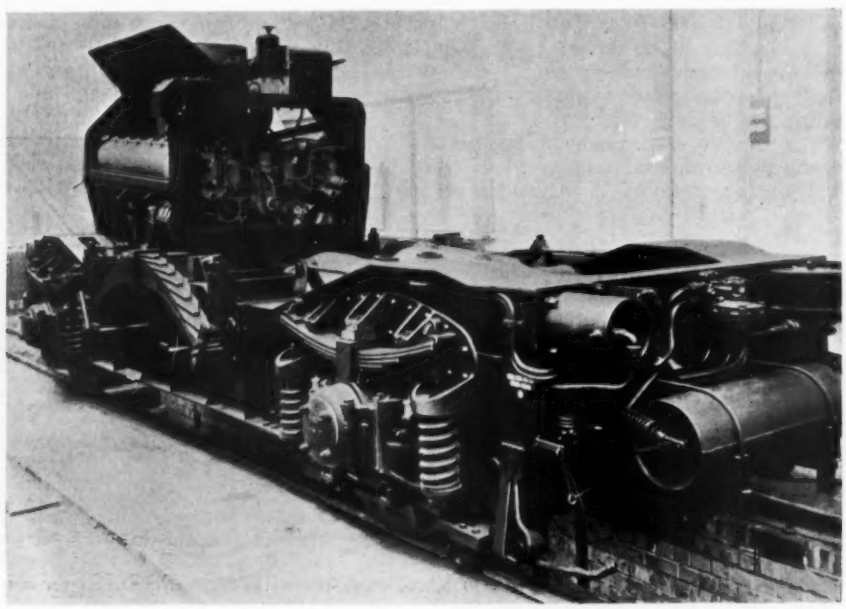
just prior to the stop. The brake cylinders, triple valves, and reservoirs are carried on the bogies, and the rigging applies two articulated blocks to each wheel.

All-steel construction has been adopted for the body framing, and the resistance to deformation of the structure was calculated to be not less than that of one of the 22-metre (72-ft.) all-steel carriages. At each passenger entrance the framework is designed as a strong double ring which assists in preventing telescoping in the event of a collision. The interior panelling and decoration is carried out in Congo woods, with chromium-plated fittings in the second class saloon and light-alloy fittings in the third class. The seats are to the same general design as those fitted to modern Belgian suburban carriages, but with a little more room. Bakelite ceilings are used, and the floors are of plywood covered with compressed wood fibre. All the windows are fixed, but some of them have sliding ventilator lights above them.

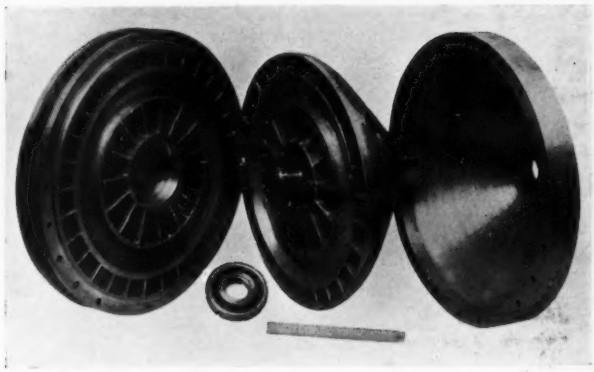
The air filtering and heating system is also of the Westinghouse type. In the summer the whole of the air is taken from the outside, and after being filtered is picked up by fans and delivered to the saloons through adjustable distributors. In cold weather the circuit is more or less reversed. An oil-fired automatically-controlled hot-water boiler is located in the centre trailer to heat the air in heaters beneath each coach; the filtered and heated air is led into the saloons through diffusers under the seats and withdrawn by the fans which in warm weather introduce the air into the saloons. With the heating equipment functioning, the air in the saloons is changed 20 times an hour, and without heating, 14 or 15 times an hour.

Power Equipment for Triple Sets

Motive power for each train is furnished by two of the well-known Maybach vee engines with 12 cylinders 160 mm. by 200 mm. Each engine is equipped with a Büchi exhaust-gas turbo pressure-charger which, with a maximum charging pressure of 4¼ lb. per sq. in., enables a top output of 600 b.h.p. to be attained at a speed of 1,400 r.p.m. The engine is enclosed in a sheet steel casing, and the air is led to it from the roof through two ducts; actually a portion of the induction air does not go



Driving bogie of modified Görlitz type with a wheelbase of 12 ft. 11½ in., carrying Maybach 600 b.h.p. engine and Voith hydraulic torque-converter group—1,200 b.h.p. triple-car trains, Belgian National Railways



Constituents of Vulcan-Sinclair fluid coupling to transmit 360 b.h.p. at 1,330 r.p.m., as used in Belgium

through the pressure-charger, but is naturally aspirated through openings in the crankcase, and helps to keep the lubricating oil and the crankcase cool. Filters are fitted at the entrances to the crankcase and also before the pressure-charger.

The engine drives a small electric generator to provide current for such auxiliary services as the compressed air supply and the lighting, and a mechanical drive is also led from the transmission to the radiator fans, which, following normal Maybach practice, are mounted with the radiators themselves on a subframe below the power car floor. A small oil-fired Westinghouse hot-water boiler is installed in each power car, and so that the cooling water can be brought up to a temperature of about 60° Cent. before the engine is started in the morning. An electrically-driven pump circulates the water when this temperature has been reached, and as soon as the engine is started this heating system is cut out of action.

The electrical control system was devised by the A.C.E.C., and is fed at a tension of 96 volts by a 240 amp.hr. Tudor battery. Regulation of the engine output is by a main control handle having one idling and five running positions. These six notches correspond to engine speeds of 600, 1,100, 1,175, 1,250, 1,325, and 1,400 r.p.m., which are obtained by the action of a servo motor. Starting and stopping of the engines are effected electrically, and the operation of the reversing gears electro-pneumatically.

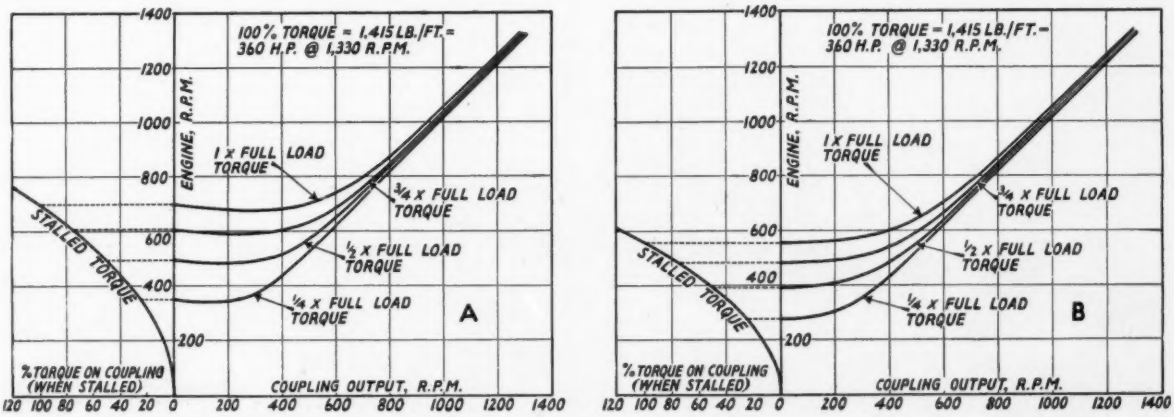
Coupled to the engine through a cardan shaft with a flexible coupling is a triple-converter Voith hydraulic transmission system with a final drive to each axle of the bogies through cardan shafts and bevel reversing gears. Between the engine and converter group is a set of speed-increasing gears, and between the converters and the axle drive are speed reducing gears of different ratios for each axle. At speeds up to 80 km.p.h. (50 m.p.h.) both axles are driven, each by one converter, and thus full use of the adhesion weight is made to gain a rapid acceleration. Between 80 km.p.h. (50 m.p.h.) and 125 km.p.h. (78 m.p.h.) the inner axle is driven by a third converter, and above 125 km.p.h. (78 m.p.h.) only the outer axle is driven, through a fluid coupling. The change-over from one combination to another is automatic.

Twin-Car Trains

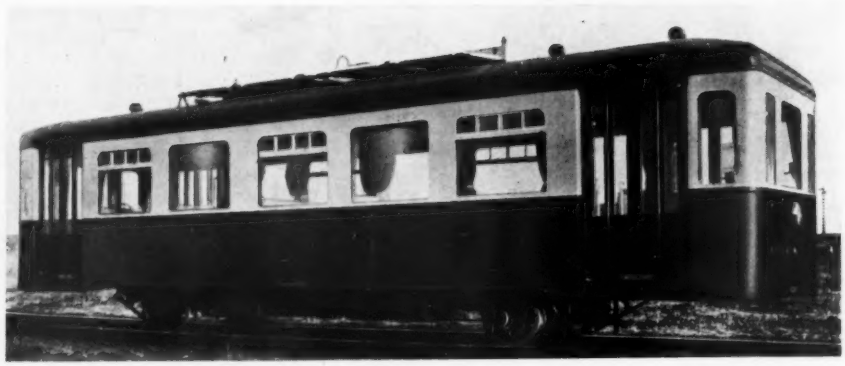
Although the general layout and construction of the mechanical portions and interiors of the twin-car sets are very much the same as in the triples, except for the articulation, the power plant and transmission are quite different. At each end of the train is an eight-cylinder vertical Carels-Ganz oil engine set to give a maximum of 370 b.h.p. at about 1,300 r.p.m. in 170 mm. by 240 mm. cylinders, and on a weight of about 6,500 lb. Each engine drives an S.L.M.-Winterthur five-speed gearbox giving track speeds of 27, 51, 80, 101, and 122 km.p.h. (16·8, 31·7, 50, 63, and 76 m.p.h.) at 1,250 r.p.m. engine speed, or a possible top speed of 127 km.p.h. (79 m.p.h.) at 1,300 r.p.m. Between the engine and the gearbox is a Vulcan-Sinclair fluid coupling, and a freewheel is incorporated in the drive.

An automatic electro-pneumatic control of the gearbox is being tried, and an ancillary feature is that in order to drive the auxiliaries fast enough when the train is standing, and to attain somewhat cleaner running of the engine during non-load periods, a relatively high engine idling speed is used, with the transmission in neutral. When the control lever is set to the preliminary first notch prior to engaging the first gear speed, the engine idling speed is temporarily decreased. Hence the drag torque on the fluid coupling is low and the work thrown on the low gear oil-operated clutch in the gearbox is reduced, as is any shock due to engagement.

The Vulcan-Sinclair fluid coupling is of the traction type, and is designed to transmit 360 b.h.p. at 1,330 r.p.m. with a slip of 3 per cent. The two graphs reproduced show the relationship between the engine revs. and the speed of the runner shaft under four conditions of load, *viz.*, at 25, 50, 75 and 100 per cent. load, and with two different fillings of the coupling. Graph B



Curves showing the relation of input speed to output speed of Vulcan-Sinclair fluid coupling; graph B shows the performance with a greater filling of the coupling than in graph A



One of the 56 four-wheel Brossel diesel-mechanical 140 b.h.p. railcars running on, or under construction for, the Belgian National Railways. The total carrying capacity is 80, on a tare of about 14 tons

shows the performance with the larger filling, giving a correspondingly higher drag torque but with a reduction in the slip.

Both express interurban trains and stopping trains to accelerated schedules are being operated by the twin-car sets. As regards speed, one of them ran from Liége to Brussels Nord on August 10 in 56 min. for the 61·7 miles, despite a maximum speed limit of 130 km.p.h. (80·8 m.p.h.). Up the celebrated Ans incline of 1 in 28-32 out of Liége, speed was maintained at 50 km.p.h. (31 m.p.h.), and the 3·6 miles from the start at Liége to passing Ans was 7 min. The 44·9 miles from Liége to Louvain, including the ascent to Ans, occupied 38 min., but west of Ans the line is almost entirely downhill.

For stopping services a fully-laden train has to be able to start in first gear with full engine torque on a gradient of 3·5 per cent. (1 in 28½), and this enables a speed of 27-28 km.p.h. (17-18 m.p.h.) to be attained in a little over three minutes. On such services stops are made on the average every 2·5 km. (1·55 miles). These twin-car sets tare 96 *tonnes* and weigh 109 *tonnes* when fully loaded.

Big Single-Unit Cars

The six large single-unit double-bogie railcars now in course of delivery are intended for heavier local traffic, and for medium-speed or semi-express interurban traffic, although they have the same transmission as the twin-car sets, giving a top speed of nearly 80 m.p.h. Second and third class accommodation and baggage room are provided in the 76½-ft. all-steel body, and totals of 64 seats and 60 standing places are provided on a tare of about 45 *tonnes;* the gross weight is 53 *tonnes*.

At one end a 370 b.h.p. Carels-Ganz engine with a Vulcan-Sinclair fluid coupling and five-speed S.L.M.-Winterthur gearbox is mounted on a four-wheel bogie having a wheelbase of 3·95 m. (12 ft. 11½ in.). The capacity, proportions, and layout of the motive power equipment is the same as in each end of a twin-car set, and the heating system of the passenger portion is on the same principle. Two big sliding doors and two narrower hinged doors on each side facilitate rapid loading and unloading.

Light Railcars

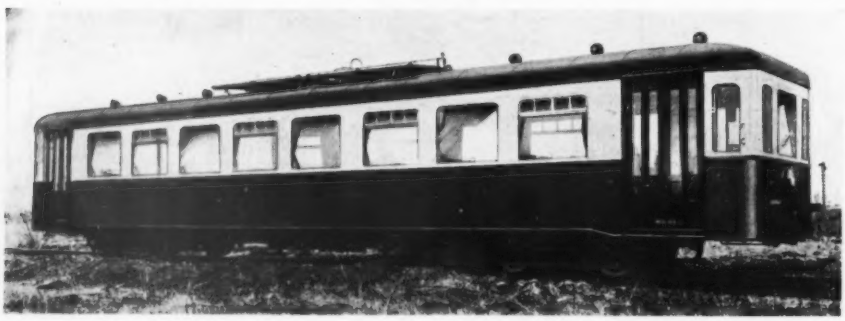
When the last constructional programme was drawn up in 1938 it was intended to build only half-a-dozen two-axle railcars and a large number of light bogie cars, but since that time the intentions have been reversed. Half-a-dozen light bogie cars and the same number of new four-wheelers are in traffic, but another 50 of the four-wheel type are being built. All 62 vehicles are of the Brossel type, and in both models a 140-b.h.p. engine is being installed.

The light all-metal bogie cars have 80 wooden seats and room for a maximum of 40 standing passengers on a tare weight of 24 *tonnes*. The gross weight is 33-34 *tonnes* and the b.h.p. per *tonne* a little over 4. A four-speed gearbox is provided and the top speed is 60 km.p.h.

Similar in construction to the six cars set to work earlier this year, the 50 four-wheel railcars on order are to have mechanical portions built at the Malines works of the Belgian National Railways, the engine and transmission equipment being supplied by Brossel. On a tare of 14½ *tonnes*, 50 seats and 30 standing places are provided, and a top speed of 60 km.p.h. (37 m.p.h.) is permitted. The four-speed gearbox drives one axle.

The Brossel engine incorporates a Ricardo Comet Mark III combustion chamber, and at 1,800 r.p.m. develops a maximum of 140 b.h.p. in six 120 mm. by 140 mm. cylinders, on a dry weight of 2,150 lb. The idling speed is 350-400 r.p.m., and the maximum torque—420 lb.-ft. —is given at 1,200 r.p.m. At full load and speed the fuel consumption is 0·41 lb. per b.h.p.hr. The cylinders and heads are cast in two blocks of three, and arrangements are made to fit either wet or dry liners as required. A single-piece light-alloy crankcase is used, and the main-bearing bolts are carried up to the cylinder heads to relieve the crankcase of the combustion stresses. Bosch fuel pumps and nozzles are fitted.

(*To be continued*)



New local-traffic bogie car of 140 b.h.p. with a total carrying capacity of 120 passengers on a tare weight of 24 metric tons; the car is of the Brossel type

Right: Wreckage of the centre and trailing end cars of the City of San Francisco diesel luxury train, with damaged girders of the Humboldt river bridge in the foreground

Below: Rail spike found out of position, allowing rail to be displaced; the track circuit bonds were in position after the accident

Bottom: General view after the accident, looking from rear end of train. (See p. 133)

SOME DIESEL EXPERIENCES IN CEYLON

By H. W. F. FREER, A.M.I.Mech.E., M.I.Loco.E.,
*Mechanical Engineer, Ceylon Government Railway**

WHEN the Ceylon Government Railway mechanical workshops were situated at Maradana the yard was quite small with a few short sidings. A steam shunting locomotive was used in the shop yard. The transfer of the workshops to Ratmalana, with eight miles of sidings, altered the position considerably. The journey to and from the shops necessitated 24 miles running daily, and although the engine could bring down vehicles for repair each morning and remove others in the evening, this work could be dealt with in other ways. The cost of such a service, including depreciation, would have amounted to Rs. 8,100 a year. As the existing shop engine was nearing the end of its useful life, a small Armstrong-Whitworth diesel-electric shunting engine was bought. Two power notches in each direction are available, and a load capacity of 300 tons round a five-chain curve at a speed of 5 m.p.h. is obtainable. One-man drives, and as he is not required to drive on the open line, a grade IV man was trained for the work. The engine works 8 hr. a day and is serviced each Saturday morning. The capital cost landed in Ceylon was Rs. 44,784 and the average operating cost is Rs. 1·64 per engine hour. Maintenance charges work out at 93 cents per engine hour. The average mileage per 8-hr. day is 25, with engine hours 4½. The total annual cost including maintenance and depreciation amounts to Rs. 5,335. A speedometer supplies the mileage figures and a Servis recorder the engine hours. The records of these two instruments are very helpful when compiling working costs.

The engine has been a success both financially and technically. Failures or defects are rare. Rapid cylinder wear was encountered at first but this has been checked by using specially treated liners. One or two cases of cracked big-end bearings were traced to imperfect adhesion of the whitemetal. The piston heads occasionally show signs of disintegration round the top ring and have to be renewed. A recent defect necessitated removal and re-soldering of some commutator connections on the traction motor armature.

Main-Line Locomotive Trials

The next venture in diesel traction was under unusual conditions. The department was approached by Armstrong-Whitworth with a proposition to demonstrate the advantages of diesel locomotives. The firm had built two 5-ft. 6-in. gauge diesel-electric locomotives and were willing to ship them to Ceylon on trial. An agreement was drawn up by which the firm employed its own staff to maintain and operate the engines on the Talaimannar mail train service. The railway provided shed accommodation, facilities for repairs, and the services of drivers—all costs being met by the firm. In return the railway paid a fixed charge per train mile amounting to 75 per cent. of the cost of steam traction on this service.

These locomotives were dogged by minor difficulties in the early stage, most of them being centred in the auxiliary power unit and fuel tanks. When these were nearly overcome further troubles arose. The armature banding wires on one of the traction-motor armatures broke and did a good deal of damage. The next major trouble was a broken crankshaft on one of the main engines; when lifting the engine for renewal of the damaged traction motor, one crane failed and the engine fell about 3 ft. 6 in. The only apparent damage was a bent axle and some twisted gussets and knees. After a general inspection the locomotive went into service. When the crankshaft failed a short time afterwards it was found that the engine bearer pads were 0.070 in. out of line. The second locomotive then failed by cracking a cylinder block. This put both locomotives out of action. The trial period of six months was up and after a discussion the makers were advised that no further trials would be permitted.

Passenger Train Requirements

The steady development of diesel-driven passenger vehicles made it clear that many railways were finding that the operating costs were economical. Ceylon could not afford to ignore the possibilities, and the coast line section with its moderately dense passenger traffic was selected as most suitable for the experiment. An exhaustive analyses of the conditions affecting the design was made. It was found that twin railcars were too small, but that a train with a capacity equal to a normal steam train would be too large, and a four-coach layout was chosen. To save weight and length it was decided to have an articulated train, and this reduced the weight of the train by about 15 tons.

A general specification was sent to England, and offers were received for the choice of two medium-power or one high-power engine. The two-engine design was finally selected, as failure of one engine did not make it necessary to send out a spare oil engine, the smaller parts would be easier to handle, but little increase in the quantity of spares held in stock would be necessary and the cost per part would be lower. The contract was awarded to the English Electric Co. Ltd.

Conditions in England caused some delay in the building of the trains, and the first one arrived in Ceylon in January, 1938. It was then found that the car bodies, which were carried as deck cargo, had suffered some damage *en route*. One power car had narrowly escaped being swept overboard. All the windows on one side were smashed and the flying glass had gashed the interior panelling in parts. Another power car and one trailer had suffered even more severely. In addition to smashed glass and ripped panelling, the whole side above the waist rail had been forced inwards about 1¾ in. Paintwork had suffered badly and salt had penetrated every crevice. The entire interior was stripped and a successful attempt made to force the damaged side back into its position with jacks.

Service Difficulties

In early service rather more difficulties than were anticipated were encountered. Traction motor failure took place twice. This was thought to be due to severe vibration of the brush gear, and bolts of 70-ton steel were tried; they failed from fatigue in a few days. It was then discovered that the motor frames had a casting defect, and each motor was tripped and the weak section built up with arc welding. An improved form of brush-gear anchorage and lighter brush boxes completed the cure.

* In a paper "Diesel Rail Traction in Ceylon," read before the Engineering Association of Ceylon.

Vibration also caused breakage and slackening of the motor suspension bearing bolts. The ordinary split pins were replaced by Palnuts, which are giving satisfaction.

Failure of the fuel-pump governor and the advance and retard mechanism gave trouble in the early stages. This has proved to be the most persistent defect and it continues at the time of writing. Apparently the gear is too light for the service, and new equipment of a more robust type is under test in England. Engines shutting down due to air in the fuel system was a regular and irritating difficulty which was only overcome by the most meticulous and painstaking overhaul of all pipe joints.

After a few weeks running unusual vibration led to an examination of the crankshaft main bearings, and excessive wear was discovered. Unsuitable lubricating oil was thought to be the cause, and it took some time to clear it from suspicion. The journals were re-turned and new undersize bearings fitted. A slight reduction in engine maximum speed and a higher oil pressure effected a cure, at the cost of a great deal of work in stripping all engines right down, and rebedding the crankshafts. One bright spot was the opportunity it gave for training the staff in repair work to fine limits.

Minor failure of electric control gear was irritating, and it was finally decided to box in the gear carefully to exclude dust and sea spray. Special attention will be paid to this in any future development. The warning signals fitted were electrically-operated Klaxon horns. They were found to be quite unsuitable for use on a railway running parallel to a public road, as trespassers on the line assumed that a lorry was coming on the road. Special air-operated two-note Desilux horns have been fitted.

The coil type motor nose suspension springs broke frequently and were replaced by rubber springs. Bogie auxiliary springs also failed, and some trouble was experienced in getting a stronger spring which could be fitted in the small space available. The fairly prevalent practice of placing stones on the rails contributed largely to the spring failure, and this has been countered by fitting rail sweeping brushes. The trains have settled down to steady service.

Maintenance Work and Equipment

With its finely fitted parts and capability for covering high mileages in short periods, the diesel engine requires careful and regular maintenance. After 1,500 engine hours in service—equal to about 37,000 miles of running—the train goes into shops for a top overhaul. This consists of decarbonising, valve grinding, crankshaft and vibration-damper inspection, timing gear adjustment, inspection of control and brake gear, examination of fan and lighting circuits, re-touching of paintwork. A general repair will be given instead of every fourth top overhaul when a mileage of about 148,000 has been run.

Nothing elaborate in the form of plant has been found necessary in the running shed. Scrupulous care is needed to ensure that the fuel oil is free from the smallest particle of dirt, and generous storage tanks help this by permitting time for settlement of the oil. An accurate flow meter for measuring fuel delivered to the trains is essential for record purposes. Water supply for radiator and lavatory tanks has to be adjacent to the fuel tanks and a careful layout of piping for both liquids is needed to ensure rapid servicing between trains.

A small motor-driven charging plant which can be plugged into the train, helps to keep the starting batteries in trim. A hand grease-gun is too slow to deal with the large number of grease nipples per train, and power-operated equipment similar to that used in garages is required. It is hoped to add a high-velocity washing spray later. A small independent room for injector nozzle testing, facilities for setting pressures, and cleaning filters is provided.

With the exception of some small experience on the shunter and trial locomotives none of the railway staff had experience on diesel work. A few promising men were picked out and given intensive training. With this nucleus a gradually expanding staff was built up by changing duties and bringing in more men for training. A useful group of men now exists which can be extended later if necessary. In anticipation of such an extension a number of promising apprentices nearing the end of their training are being drafted on to diesel work. Supervisory staff is being dealt with in the same way. For driving, ten of the younger qualified Singhalese steam engine drivers were selected and trained. The total cost of the trains ready for service was Rs. 271,333 each. Neglecting residual value, this sum plus interest has to be covered in a 15-year life. Assuming interest on capital at 2½ per cent. and a sinking fund at 2½ per cent. compound interest the standing charges a year will be:

Interest	Rs. 6,784
Depreciation	,, 15,121
Total	Rs. 21,905

The actual average monthly mileage is 7,500, but due allowance must be made for time spent in shops. This reduces the figure to an average of 6,520 miles per month. The standing charges therefore amount to 28 cents a mile. This represents about 31 per cent. of the total cost per mile and emphasises the need for maintaining high annual mileage figures.

Direct operating costs have been watched carefully and have been reduced into terms of cents per mile, as follow:

	Cents per Mile
Running maintenance of engines, traction motors, power bogies and control gear	6·23
Coach, running maintenance	1·54
Shed and yard services	7·92
Stores and lubricants	3·61
Drivers' salaries	7·62
Guards' salaries	8·38
Cleaners' wages and materials	1·51
Fuel oil	8·16
Sundries	0·90
Total	45·87

The overhead charges for shed buildings and plant are not available.

To date no actual information on shop maintenance costs is available as shop repairs have not been carried out yet. The following figures are estimated and are considered to be on the safe side:

	Cents per Mile.
General repairs	10
Renewals	6
Total	16

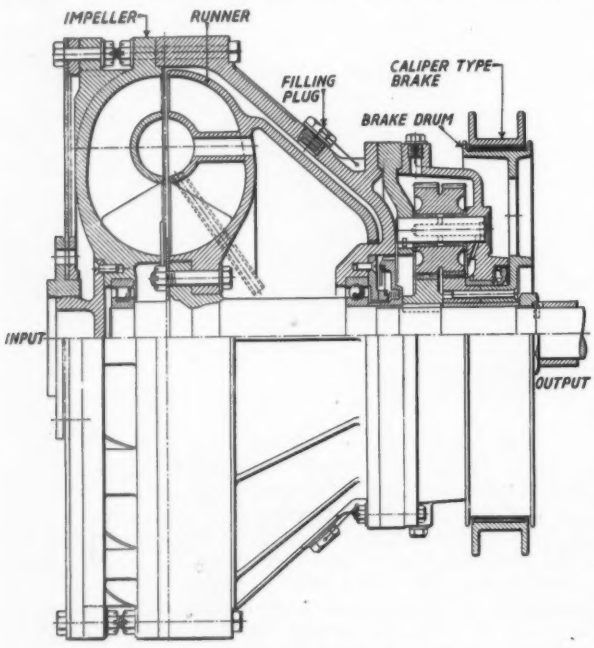
These figures include all workshop overhead charges. The amount provided for renewals is approximately 66 per cent. of the total amount required to replace the engines and traction motors once during the life of the train, but this sum will hardly be required unless a smash-up is experienced. The total cost of running the trains may therefore be taken as 90 cents a mile. With a greater number of trains in service the shed charges could be reduced slightly owing to better usage of labour and plant. Ignoring the standing charges, the operating and maintenance charges for steam trains may be taken as, very roughly, Rs. 1·39 per train-mile.

Fluid Couplings

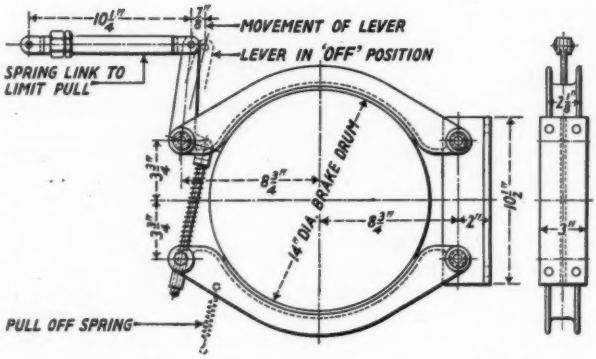
Improvements in the construction of the Vulcan-Sinclair products

DETAILED modifications are constantly being made in the construction of the Vulcan-Sinclair fluid couplings, and the two accompanying drawings show the latest form of the traction type coupling with idling drag eliminator, which is nothing more than a form of rocking brake deriving the force for backward rotation against the drag torque from the idling power of the engine. The brake drum is connected to a sun pinion meshing with pairs of planet wheels mounted on a planet carrier bolted to the casing, which rotates with the engine; a second sun wheel of slightly smaller diameter is keyed to the runner shaft. At ordinary running speeds the epicyclic train rotates as a unit, with practically no relative motion of its elements. When the engine is idling with the output shaft running free, the application of the drag brake applies a retarding torque through the planet wheels of the sun pinion on the runner shaft, and brings it to rest; it then rotates very slowly backwards to facilitate the engagement of the gear. If the runner shaft is stalled in gear with the engine idling, the brake drum will rotate forwards very slowly. Hence when the brake is applied through the Ferodo shoes, the effect is to turn the runner shaft very slowly backwards, thus releasing the drag torque so that the drive can be disengaged and another dog clutch readily meshed. A spring link in the drag brake actuating rod serves to limit the braking force to well within the capacity of the gear, and the drag eliminator is thus safeguarded against torque loads materially higher than the normal idling drag.

In the coupling shown on this page a special method of mounting on the engine crankshaft is employed, namely, by means of a steel diaphragm driving disc. The coupling is registered for concentric running by a spherical centre spigot of steel, and the coupling flange bolts pass through clearance holes in the disc to permit creep due to differential expansion. The steel diaphragm is slightly resilient, as is desirable to introduce some degree of flexibility between the engine crankshaft and the outboard bearing, thus minimising the effects of crankshaft deflections and wear of the main bearings, which, in the case of a rigidly-mounted coupling, would cause undesirable vibration loads to be transmitted to the runner shaft and outboard bearings. For the foregoing reasons it is not considered good practice for the high-tensile aluminium-alloy impeller to be bolted through its boss to the crankshaft flange; also in that case any work involving removal of the fluid coupling would necessitate it being opened up.



Traction-type coupling with idling drag eliminator and diaphragm drive to obviate trouble due to crankshaft bearing wear or runner shaft vibration



End view of caliper brake and its mechanism forming the idling drag eliminator

NOTES AND NEWS

Rosario Locomotive Service.—In 1931 Sulzer Bros., of Winterthur, supplied three 330-b.h.p. double-bogie shunting locomotives to the Port of Rosario authorities. Up to the end of February, 1939, the first of these locomotives had covered 101,096 km. in 27,584 working hours, the second 110,963 km. in 29,872 working hours, and the third 124,028 km. in 33,408 working hours.

Ruhr Express Diesels.—The change-over of the Ruhr express services to diesel railcar working, which has for some time been a wish of the industrialists in this area, is to be taken in hand in 1940, and by 1944, according to present plans, 300 railcar units will be in service for this traffic, each unit consisting of a railcar and two driving trailers.

German Triple-Car Train.—Among the railcar sets which have given successful results in local traffic is a triple-car unit on the standard-gauge Braunschweigische Landes-Eisenbahn. It comprises a six-wheeled power and passenger car in the centre, and a double-bogie driving trailer at each end, all of which were converted from existing vehicles. Power is provided by a six-cylinder M.A.N. engine giving 190 b.h.p. at 1,000 r.p.m., which, with the Brown Boveri main generator, auxiliary compressor, and starting air bottles, is mounted on a single welded steel bedplate supported by the car longitudinals. There is a traction motor on each end axle of the 28-ton power car. Overall the train measures 129 ft., and has seating accommodation for about 165 passengers. The top speed is 28-30 m.p.h., but if the car is running with only one driving trailer a speed of 37-38 m.p.h. is attained. The set was put into service in 1934, and averages about 50,000 miles a year on slow-speed runs.

Diesel Railway Traction

Stainless Steel

THE increasing use of railcars and carriages built of stainless steel on the Budd system focuses attention on some of the peculiarities of the 18 per cent.-chromium and 8 per cent.-nickel steel used. For example, a method had to be devised to join the stainless steel plates and sections, and as in alloy steel construction soft rivets do not enable the full strength of the material to be used, and hard rivets are difficult to drive satisfactorily, the now well-known Shotweld system was evolved. This low-voltage high-amperage electric welding method was referred to in the issue of this Supplement for March 22, 1935; its advantage is that the harmful effects of normal welding on the stainless steel are eliminated. A peculiarity of this stainless steel, with its high chromium and nickel contents, is the tendency to precipitation of chromium carbides from solution into the grain boundaries at a temperature range of 800 to 1,500° F.; this depletes the chromium, with a corresponding loss in corrosion resistance, one of the principal advantages of stainless steel. The problem of the resultant intergranular corrosion was solved by reheating the steel to about 2,000° F. and then quenching. As it requires time to precipitate the carbide, the Shotweld process does not assist this action, for the current is on only for a very short time, and by the correct proportioning of weld and electrode sizes heat dissipation is quick, and the metal is almost cold before the carbides have had time to precipitate. Normally, the ultimate strength of this 18-8 stainless steel is 150,000 lb. per sq. in. as a minimum, and the elastic limit 115,000 to 120,000 lb. per sq. in., but before cold working the ultimate strength is no more than 90,000 to 100,000 lb. per sq. in.

Crankcase Oil

ACCORDING to a report of the Mechanical Division of the Association of American Railroads, there is a considerable range in the specifications of crankcase oil used by those roads operating diesel-powered high-speed main-line trains, the majority using such an oil approximately to the S.A.E. 50 specification. Many of them purchase oil for this purpose by brand. Those roads operating locomotives in switching service also use a wide range of crankcase oil, but generally an oil somewhat heavier than S.A.E. 50, with a tendency to vary the pour point between summer and winter, depending upon the territory in which the operation is carried on. The practice as to mileage between oil changes is as varied as the source of supply. In road service the railroads reported oil changes ranging from 2,500 miles to 10,000 miles, and in yard service from three months to 25,000 miles. This wide variation may be explained in part by the use of continuous filters located upon the unit in some cases, and in other examples by the nature of the service performed. In view of the claims of the damaging effect of acidity in crankcase oil, the Mechanical Division's questionnaire was designed to show up any troubles from this source and the method of correcting them. The 13 roads operating diesel locomotives advised they had experienced no difficulties traceable to acidity in crankcase oil. One or more roads advised they had arranged their oil changes in order to avoid development of acidity and apparently had been successful. On one particular line the practice has been adopted of taking weekly samples of oil from the crankcases of all diesel engines and sending them to the laboratory for analysis. It has been found that the viscosity and precipitation number are the most important elements in the analysis, and, as a result of this practice, it has now become possible, on one class of diesel-electric locomotive, to limit the oil changes to one every 12 months, subject, however, to the weekly laboratory analysis. Other views are that the successful lubrication of railway oil engines depends to a great extent upon the efficacy of the filters and cooling equipment.

City of San Francisco Derailment

MR. A. D. McDONALD, President of the Southern Pacific Railroad, has issued a statement about the accident to the diesel streamliner *City of San Francisco* on August 12 (see issue of this Supplement for September 1), in which he reports that an examination of the track immediately after the accident revealed that spikes were removed from ten sleepers, and the fishbolts and fishplates between two rails were removed, permitting the criminal or criminals to force the rail 4 in. out of line, in which position it was spiked down to serve as a derailing switch. Care had been taken not to interfere with the flexible bond wires between the two rails, which, if broken, would have broken the track circuit, automatically setting the block signals at the stop position. The rails at the scene of the accident are of 130-lb. section; the track is rock-ballasted and all the sleepers were in good condition. Mr. McDonald's statement emphasises the strength of the modern lightweight stock in the train, and considers that it did much to save the lives of passengers in the train. Of the 17 units, including the three-section locomotive, only five—two sleeping cars and three other cars—were damaged to such an extent that they will have to be replaced by new cars. The other six sleeping cars suffered damage estimated at $70,000. The way in which the stock stood up to the derailment occurring at a speed of something like a mile a minute is well shown in the illustrations appearing on p. 145 of the issue of this Supplement for September 1. The car framing is of the girder type, and the centre sills, side sills and pillars are of aluminium alloy; they carry side panel and roof sheets of the same material. The end sills, bolsters and needle beams are of high-tensile alloy steel, of welded construction. The floors are of pressed aluminium sheet. Welded high-tensile steel is used for all the stress-bearing members of the framing of the three-section 6,300 b.h.p. diesel-electric locomotive, but the construction of the non-stressed sides is unusual in that the outer panels are of plywood covered with galvanised steel. The two rear units of the locomotive were derailed in the accident, but did not strike the bridge girders.

THE NEW ARGENTINE EXTENSION

Further details of the Anglo-Hungarian diesel stock to be built at a cost of nearly £300,000 for important interurban business services

A view of Retiro station, Buenos Aires, showing Ganz triple-car suburban train, and also single-unit cars coupled in multiple-unit and operating suburban services

THE order for 10 triple-car diesel trains and seven bogie railcars which, as announced in our issue of September 1, has been placed with Metropolitan Railcars (Ganz Patents) Limited by the Argentine State Railways, covers the supply of vehicles at practically the same price as those built five years ago and subsequently, but apparently certain improvements in these new trains and cars are to be installed in the existing vehicles free of charge.

A decree authorising the purchase of the 10 triple-car 640 b.h.p. (not 480 b.h.p. as would be inferred from our September 1 issue) trains at a price equivalent to £242,480 and seven single-unit 240 b.h.p. cars at a price of £51,037, emphasises the numerous requests that have been made for railcar traction between important cities, and considers that the necessity for such railcars and railcar trains is now imperative. The decree also notes the desirability of uniformity of the stock when existing units have been satisfactory in performance and in price, the question of quick delivery, and finally the willingness of the government of Hungary (in which country the vehicles are to be built by Ganz & Co. Ltd.) to increase the quantity of imports from Argentina.

Present Stock

At the moment, the Argentine State Railways have in service 74 single-unit double-bogie diesel-mechanical railcars and 11 triple-car diesel-mechanical trains. All these are of Ganz manufacture, and have covered a mileage in excess of 5,000,000. Of the triple-car trains, two are of a luxury type and cater for the tourist traffic on the long broad-gauge route between Viedma and the Argentine national park at Bariloche; they were described in detail in the issue of this Supplement for April 15, 1938. Four of the remaining triples are for medium-distance and long-distance traffic on metre-gauge lines, and five are for suburban traffic on the metre-gauge system. The single-unit railcars are running on 5 ft. 6 in., 4 ft. 8½ in., and metre-gauge lines. The broad-gauge cars operate on the isolated sections from Puerto Deseado to Colonia Las Heras, and from Comodore Rivadavia to Col Sarmiento, both far south of Buenos Aires. These cars were shipped in sections to the ports of Puerto Deseado and Comodore Rivadavia, whereas the standard- and metre-gauge cars were divided only into the bogies and the body, and were shipped to the River Plate.

New Vehicles

The new stock is intended to improve services in the Salta, Tucumán, Cordoba, Rosario, Santa Fe and Buenos Aires districts. The trains are of the non-articulated type, and will weigh nearly 150 tons when carrying the full complement of 158 passengers (including 44 in the diner), luggage and mail. A restaurant-car service is provided, the kitchen being in one of the end cars, which also contains 16 first class and 28 second class dining-car seats. Very generous space has been allowed for mail and luggage. An eight-cylinder 320 b.h.p. Ganz engine and gearbox are mounted on each end bogie, and in view of the size and weight, and the strictly limited axle load on the metre-gauge lines, these two driving bogies are of the six-wheel type, with the centre pair of wheels flangeless. The top speed is 110 km.p.h. (68½ m.p.h.), considerably higher than can be attained by the A.S.R. steam trains under the

rather unfavourable track conditions. Actually, this higher top speed and quicker acceleration enable the diesels to cut the steam train times by about 40 per cent. on the important interurban services.

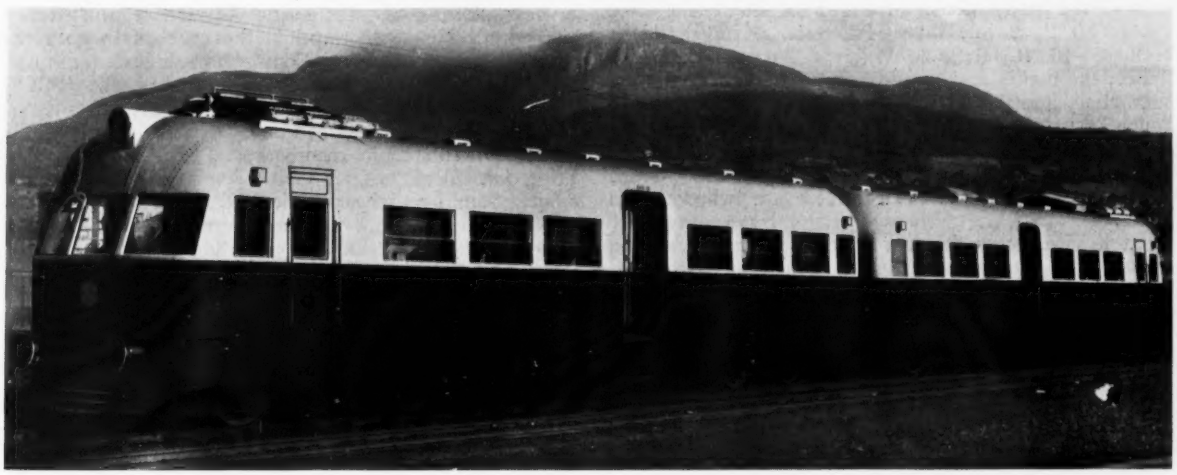
Experience has indicated that the existing metre-gauge Ganz triple-car diesel trains on the Argentine State Railways operate at a cost of a little over a shilling a mile exclusive of financial charges, and this is made up as follows:

Fuel and lubrication	2·1d. a mile
Maintenance and repairs	7·7d. ,,
Driving crew wages	1·5d. ,,
Train crew wages	1·3d. ,,
Total	12·6d. ,,

A steam train weighing 400 tons or more including the locomotive, and having the same passenger accommodation, costs appreciably more to operate, although no figures from the A.S.R. are available.

Certain of the existing diesel vehicles of the A.S.R. are fitted with air-conditioning, and in the design of all of them some attention was paid to making the saloons and mechanical details dustproof, but actual operation has proved that the requirements in both these fields need very special attention because of the climatic extremes and the dust and volcanic ash storms found in Argentina. Consequently the cooling capacity of the air-conditioning equipment has been more than doubled—from 48,000 to 100,000 cold calories an hour—and the arrangement changed to give a more even system of air distribution. To prevent the ingress of dust, even when driven by wind, double glass panes are used in the windows, the doors are closed and held tight shut by means of compressed air, and emergency ventilation is provided. Larger axle journals and improved dust pads are to be fitted, and special oil-bath filters are to be fitted to the engine air intakes. In the engines themselves, aluminium alloy pistons will be used. The construction of the mechanical portion is along Ganz standard lines, with body framing of welded chrome steel.

MORE RAILCARS FOR TASMANIA



Two of the new diesel-mechanical railcars coupled in multiple-unit

WITHIN the last year or two the Tasmanian Government Railways have converted eight of their petrol-engined railcars, seating 22 to 46 passengers, to diesel power, using a Gardner 6LW engine of 102 b.h.p. in four cases and a 68 b.h.p. 4LW engine of the same make for the remainder. In addition, six new diesel cars and two special trailers are being introduced into traffic. Four of the new railcars are powered with a Gardner 6LW engine, and two with a 6L3 Gardner engine set to give 153 b.h.p. at 1,200 r.p.m. The car bodies and underframes have been built by the Waddington Body Co. Ltd., located at Granville, New South Wales, and the power bogies, complete with engine and transmission, have been supplied by the Drewry Car Co. Ltd. In each case the engine works in conjunction with a Vulcan-Sinclair fluid coupling and a Wilson-Drewry preselective epicyclic gearbox with electro-pneumatic operation from the control desks. Only one axle is driven. Multiple-unit control is embodied. The cooling water radiator is carried on the roof. Both the power and trailing bogies are fitted with roller-bearing axleboxes, the Timken make being used for the power bogie and S.K.F. for the trailers. Westinghouse brakes apply blocks to all wheels.

The cars measure 47 ft. 1½ in. long overall and have a width of 9 ft., although the rail gauge is only 3 ft. 6 in. The power bogies have a wheelbase of 9 ft. and the trailing bogies 5 ft. 3 in., and they are pitched at a distance of 31 ft. 6 in. apart. The aggregate weight of the power and trailing bogies in each coach is 7½ tons, and the underframe and body just over 12 tons, giving a car weight in working order but without passengers of just under 19¾ tons. The trailing bogies are to the Tasmanian standard design for light coaches. One-class accommodation only is provided and there are 50 seats. The cars with the 153 b.h.p. engines are intended for longer-distance services and are provided with lavatory accommodation.

All-steel body framework has been adopted, and is covered with aluminium-alloy side panels and roof. The seats are of an up-to-date tubular-frame pattern and are upholstered in green leather. Electric lighting is fitted and incorporates modern opalescent lamp fittings in the ceiling. Entrance and exit are by two doors on each side of the car. Externally the cars are painted green below the waistline and cream above. A driving cabin is provided at each end so that there is no necessity for the use of turntables.

The special trailers are of similar construction, and on a tare weight of 10 tons carry 62 one-class passengers. The body is 44 ft. 6 in. long and 9 ft. wide, and is supported on lightweight bogies with centres pitched at 31 ft. 6 in.

LOCAL RAILCARS IN FRANCE

Solo and trailer-hauling services in country and town districts

THE Chemins de fer Secondaires du Nord-Est operates a wandering system of standard-gauge, metre-gauge, and 60-cm. lines in the vicinity of Laon, Soissons, and St. Quentin, and two isolated systems near Lille and Bar-le-Duc. One of the lines is operated as an electric tramway; the others are worked by steam locomotives and railcars with internal-combustion engines, all the latest types of which are diesel-engined.

Four Wheelers

Three types of Renault diesel railcars are in use for general passenger traffic, two with four wheels and one of the double-bogie pattern. The smallest, the Renault ZP type, carries 37 passengers on a tare weight of 7½ tons, and is equipped with a six-cylinder Renault road transport engine developing 75 b.h.p. at 1,600 r.p.m. and driving through a three-speed gearbox giving a maximum track speed of 75 km.p.h.(46½ m.p.h.). The overall length of the car, which is arranged for single-end drive only, is 30 ft. 9 in., the width 8 ft. 6 in., and the wheelbase 16 ft. 9 in. Following normal Renault practice, the bodies and framing are of all-welded all-steel construction, and the monobloc steel wheels are air-braked through drums on the inner surfaces; the axles are supported in the Timken type of tapered roller bearings, and hydraulic shock absorbers are fitted to the chassis. Despite the small size of the car there are two doors on each side.

Next in size comes the four-wheeled 20 model, seating 29 passengers, and having room for 10 standing passengers and nearly half-a-ton of luggage and parcels. This car has double-end drive and is arranged to haul light trailers. It tares 9 tons, measures 39 ft. 6 in. in length, 9 ft. 4 in. in width, and has a wheelbase of 20 ft. 6 in. The engine is set to give a maximum of 120 b.h.p. at 1,500 r.p.m., and through a Renault four-speed gearbox can propel the car, working solo, at a top speed of 95 km.p.h.(60 m.p.h.), although this is never attained in service. Up grades of 1 in 42 the speed is 58-59 km.p.h.(36-37 m.p.h.). Sanding is fitted for use during both accelerating and decelerating periods. Electric lighting and exhaust-gas heating are incorporated. For rapid loading and unloading in the urban areas, the side doors are opened and closed by air motors under the control of the driver.

Bogie Cars

The largest car is the old version, type VH, of the Renault bogie car with double-end drive as used in large numbers all over France, and is powered by a 12-cylinder vee engine set to give 250 b.h.p. at 1,500 r.p.m. in cylinders 130 mm. by 170 mm. and driving the two axles of one bogie through a four-speed Renault mechanical transmission with the usual multi-bevel and vertical shaft drive. The cooling radiator is carried on the roof. This type of vehicle seats 70 passengers on a tare weight of 25 tons and within a length and breadth of 61 ft. 3 in. and 9 ft. 6 in. respectively; the luggage and light goods capacity is 1¾ tons. A top speed of 93 km.p.h.(57½ m.p.h.) is permitted, and up 1 in 42 the top speed is 57-58 km.p.h. (35·36 m.p.h.); the car has to go round curves of 260 ft. radius. Compressed air brakes are used and apply two blocks on each monobloc wheel. S.K.F. roller-bearing axleboxes are used. The body framework is built up of alloy steel in the usual Renault fashion, the sides being the main members and the roof and sides being formed as ties. The interior panels are insulated against sound and heat. Air is distributed through the passenger saloon by a simple form of pressure ventilation with adjustable distributors. Heating is effected by the exhaust gases from the engine, and the lighting current is supplied through a cadmium-nickel battery charged by an engine-driven dynamo. These cars haul trailers when required.

From 1929 onwards a number of other railcars have been used on 95 route km.(60 miles) of the metre-gauge lines near Soissons and Rethel, and during 1937 the seven cars then in traffic covered an aggregate of 405,810 km. (252,000 miles); one of the seven is a Brissoneau & Lotz 135 b.h.p. diesel car with electric transmission, and a welded and riveted body made of chrome-copper steel; the other six are petrol-engined cars of a variety of makes.

Interior and exterior of the Renault 75 b.h.p. ZP type railcar; extra seats are provided down the central gangway for use during rush hours

DIESEL TRACTION ON THE BELGIAN NATIONAL RAILWAYS

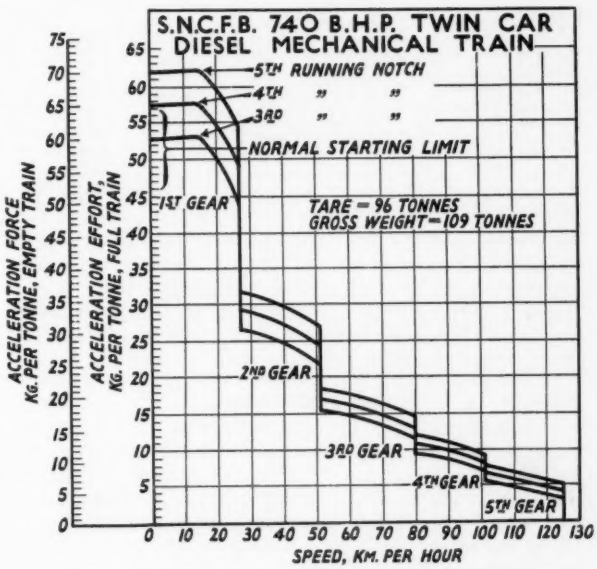
The services, maintenance and repairs, and working costs of the single-unit cars, triple- and twin-car trains in local and express services

(*Continued from p. 144, September 1 issue*)

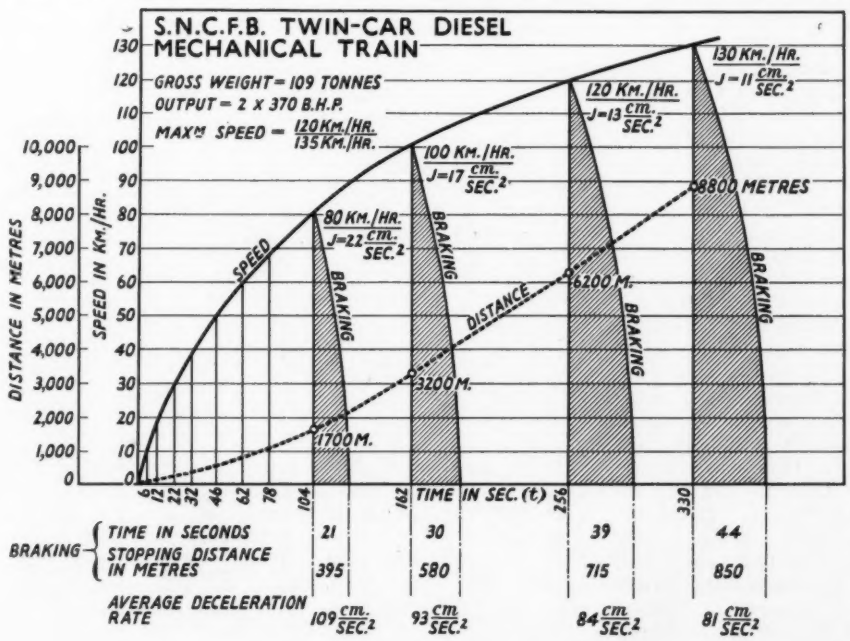
INFORMATION on the characteristics of the new twin-car articulated 740 b.h.p. diesel-mechanical trains with Vulcan-Sinclair fluid couplings and five-speed gearboxes is given in two of the accompanying illustrations. With 6·8 b.h.p. per *tonne* of gross weight, the train can accelerate on the straight level from rest to 100 km.p.h. (62 m.p.h.) in 162 sec. and in a distance of 3,200 m. (3,500 yd.), and to 130 km.p.h. (80·8 m.p.h.) in 330 sec. and 8,800 m. (9,620 yd.). From rest up to 56 km.p.h. (35 m.p.h.) the acceleration is at the rate of 1 km.p.h.p.s. (0·62 m.p.h.p.s.) or more, but taken from zero up to the top service speed of 130 km.p.h. (80·8 m.p.h.) the average rate is only 0·395 km.p.h.p.s. (0·245 m.p.h.p.s.).

Westinghouse brakes apply two blocks per wheel through clasp rigging, and on the level the fully-laden train can be stopped from 80 km.p.h. (50 m.p.h.) in 21 sec. and within a distance of 395 m. (432 yd.); from 120 km.p.h. (75 m.p.h.) in 39 sec. and within 715 m. (782 yd.); and from 130 km.p.h. (80·8 m.p.h.) in 44 sec. and within 850 m. (930 yd.). From 80 km.p.h. (50 m.p.h.) the average rate of deceleration is 1·09 m.p.s.p.s. (3·57 ft.p.s.p.s.), and from 130 km.p.h. (80·8 m.p.h.), 0·81 m.p.s.p.s. (2·66 ft.p.s.p.s.).

Performance data obtained from the 210 b.h.p. double-bogie diesel-electric railcar (Type 651) when operating on accelerated stopping (*trottinette*) services between Brussels and Ottignies, were given in the issue of this Supplement for August 7, 1936. It was then shown that on the run of 19 miles with 10 or 11 stops the engine was working at full output for 67 to 76 per cent. of the time. The acceleration rates varied from 0·48 to 0·8 m.p.h.p.s. up to 30 m.p.h., the lower rate being obtained on a gradient of 1 in 117. Full engine power was used almost from the start until a brief period of coasting before the brake application, the engine turning at its top speed of 1,400 r.p.m. for anything up to 91 per cent. of the time taken between a start and the succeeding stop. The deceleration



Acceleration force curves of 740 b.h.p. twin-car diesel-mechanical trains built this year



Performance curves showing acceleration and deceleration on the straight level of one of the 740 b.h.p. diesel-mechanical twin-car trains with five-speed gearboxes. The b.h.p. per ton of gross weight is just under seven

TABLE I.—MILEAGE AND UTILISATION OF DIESEL CARS AND TRAINS, BELGIAN NATIONAL RAILWAYS*

Year placed in service	No. of railcars or trains	Type and arrangement	Class No.	B.H.P.	No. of seats	Distance covered since going into service, km.		Number of railcar days since going into service			Average distance per railcar		Coefficient of Utilisation *a*/*b*
						Total	Per car	Calendar	Out of traffic†	Utilised	Per calendar day (*a*)	Per day utilised (*b*)	
1930	3	Diesel-mech.; bogie ..	600	175	92	2,255,940	751,980	9,549	2,600	6,949	236	325	0·72
1932	1	Diesel-elect.; bogie ..	650	200	80	587,690	587,690	2,508	914	1,594	234	369	0·63
1933	14	Diesel-mech.; bogie ..	601	175	104	7,208,140	514,867	28,890	7,278	21,612	250	334	0·75
1934	1	Diesel-mech.; bogie ..	602	210	100	338,860	338,860	1,645	633	1,012	206	335	0·60
1934	1	Diesel-elect.; bogie ..	651	210	100	324,957	324,957	1,495	547	948	217	343	0·63
1934	1	Diesel-elect.; twin ..	652	410	185	289,969	289,969	1,685	907	778	172	373	0·46
1934	1	Diesel-mech.; 2-axle ..	603	140	57	193,299	193,299	1,495	631	864	129	224	0·57
1934	5	Diesel-mech.; 2-axle ..	604	120	60	1,346,096	269,213	8,380	2,313	6,067	161	222	0·72
1935	1	Diesel-mech.; bogie ..	605	220	100	140,760	140,760	1,162	688	474	121	297	0·40
1936	1	Diesel-mech.; bogie ..	606	320	70	199,104	199,104	1,049	407	642	190	310	0·61
1936	1	Diesel-mech.; bogie ..	607	330‡	70	41,300	41,300	961	795	166	43	249	0·17
1936	3	Diesel-elect.; triple ..	653	820	229	1,047,523	261,881	3,126	772	2,354	335	445	0·75
1936	3	Diesel-elect.; triple ..	654	730	229	860,005	286,668	2,940	852	2,088	293	412	0·71
1936	1	Diesel-elect.; triple ..	655	900§	229	71,672	71,672	667	450	217	52	438	0·11
1936	1	Diesel-elect.; triple ..	656	800‖	229	126,736	126,736	817	521	296	155	428	0·36

* Figures to end of 1938. † For any reason. ‡ Now replaced by ex-450 b.h.p. engine from Type 655, derated. § Now replaced by two engines aggregating 820 b.h.p. ‖ Now a twin-car train with one 400 b.h.p. engine. For fuller particulars of cars see p. 139, September 1 issue.

rates were high, stops being made from 59 m.p.h. in 24 sec., and from 55 m.p.h. in less than 20 sec. Many *trottinette* services are still worked by diesel cars, but this Brussels—Ottignies service, covering 19 miles of difficult line in 33 min. down and 31 min. up inclusive of nearly a dozen stops, has been withdrawn.

Services

The eight triple-car sets of 1936 build and the 410 b.h.p. twin-car formation introduced in 1934, have worked mainly business services between the Belgian capital and Ghent, Ostend, Charleroi, Mons and Liége, and also certain turns between Brussels and Namur. From Brussels (Midi) to Ostend the 72·1 miles were covered in 64 min. at an average of 67·7 m.p.h., the intermediate booking for the 32·9 miles from the Midi terminal to Ghent (St. Pierre) being 28 min., an average of 75·2 m.p.h. This Ostend service was accelerated during the past summer and worked by new streamlined Atlantic steam locomotives. The steeply-graded Midi—Charleroi line, with banks of 1 in 77 down and 1 in 165 up is covered start-to-stop in 40 min. for the 34·8 miles at an average of 52·2 m.p.h. The Liége services to and from Brussels are operated at 54-55 m.p.h. over the 61·7 miles; the maximum grade eastbound is 1 in 200, but westbound the start from Liége (Guillemins) is up the formidable Ans incline at 1 in 28-32.

Since the beginning of August last these services have been altered somewhat, to include fast trains worked by the six new 1,200 b.h.p. triples, and lines with express services operated by the two batches of triple-car 800-820 and 1,200 b.h.p. trains are now Brussels—Liége, Brussels—Bruges—Knocke; Brussels—Ghent—Adinkerke; Brussels—Lille; Brussels—Mons; and Brussels—Charleroi. These, and the widespread network of local services operated by single-unit cars, were shown in the map reproduced on p. 141 of the issue of this Supplement for September 1. A number of the new diesel-hydraulic triples have also been at work on the Brussels—Charleroi and Brussels—Mons services, as well as those shown on the map just mentioned.

Prior to the August service, two of the eight 1936 triples were at any one time considered as under repair or standing as second spare, and one car—with staff—was held as reserve at Brussels (Forest depot). The five remaining cars were rostered to cover about 2,130 miles a day on five turns. The first turn, with a single crew, totalled 202 miles, but several hours were set aside for the weekly maintenance; the second turn, with two crews, comprised 491 miles; the third service, with two crews, totalled 435 miles; the fourth service, also with two crews, 515 miles; and the fifth turn, with three crews, 489 miles. The daily average of the five triples actually in traffic was thus 426 miles, but spread over the eight sets the average was 265 miles a day.

Mileages

From going into traffic in the summer of 1934 until the end of 1938, the 410 b.h.p. twin-car train had covered 289,969 km. (180,000 miles); this low mileage was due partly to its service being confined mainly to the short Brussels—Ghent run, and partly owing to the amount of experimental work and tests undertaken, and which led to the later triples. The three Type 653 triples were put into traffic between May and October, 1936, and until the end of December, 1938, had covered an aggregate of 967,000 km. (600,000 miles). The three Type 654 sets, each powered by two eight-cylinder Carels-Ganz engines, put into traffic at the same time, had covered 860,005 km. (535,000 miles) by the end of 1938, whereas the Frichs-engined triple had run only 126,736 km. (78,750 miles) in the same period, and the triple with two Mercédès engines 81,000 km. (50,330 miles). The performance of the two last-named sets was mentioned on pp. 138-9 of our September 1 issue.

Mileages of the various types of single-unit cars on the Belgian National Railways will be found in Table I. As all the single-unit cars listed are engaged solely in local services at slow to moderate speeds, and making anything from 100 to 200 stops a day, the mileages are quite nominal. The first Maybach cars have now been in service for nearly 10 years and have an average yearly mileage of 52,000 per car to their credit; the 14 cars of similar but improved design set to work in 1933 have covered an average of about 56,000 miles a year per car. The two low-powered diesel-electric cars, Types 650 and 651, make comparatively low mileages.

TABLE II.—RAILCAR MILEAGE, 1930-38, BELGIAN NATIONAL RAILWAYS

Year	Aggregate yearly distance, km.	Average monthly distance, km.	No. of railcars at end of year
1930	216,962	18,080	6
1931	456,841	38,070	6
1932	680,039	56,670	7
1933	1,286,531	107,210	22
1934	2,485,616	207,135	31
1935	2,631,792	219,316	32
1936	3,093,654	257,805	42
1937	3,282,742	273,625	42
1938	3,483,885	290,323	42

Taken generally, the monthly mileage of the triple and twin sets engaged in express service is 11,200 to 12,500, whereas for the single-unit cars in local traffic it is 5,500 to 6,250 per car in traffic; over the whole stud of single-unit cars the monthly mileage is only 4,800 to 5,000, this being due to the number of depots over which a hitherto small number of cars has been spread, with a consequent high proportion—20 to 25 per cent.—of cars held in reserve.

All the multi-unit trains are shedded at Brussels (Forest depot near the Midi station), but the railcars are divided between the depots at Bruges, Berchem (Antwerp), Meirelbeke (Ghent), Liége, and Haine St. Pierre. Before the introduction of the six new triples, 12 new twins, six new 370 b.h.p. singles, and the 140 b.h.p. Brossel singles, the three cars at Bruges were scheduled to cover 135,000 miles a year, the eight cars at Meirelbeke 403,000 miles, the six at Berchem 270,000, the 12 at Haine St. Pierre 477,000, the single diesel car at Liége 28,000, and the eight triples at Forest depot, 670,000 miles a year. Leading particulars of all the cars and trains will be found in the first instalment of this article, published in the September 1 issue.

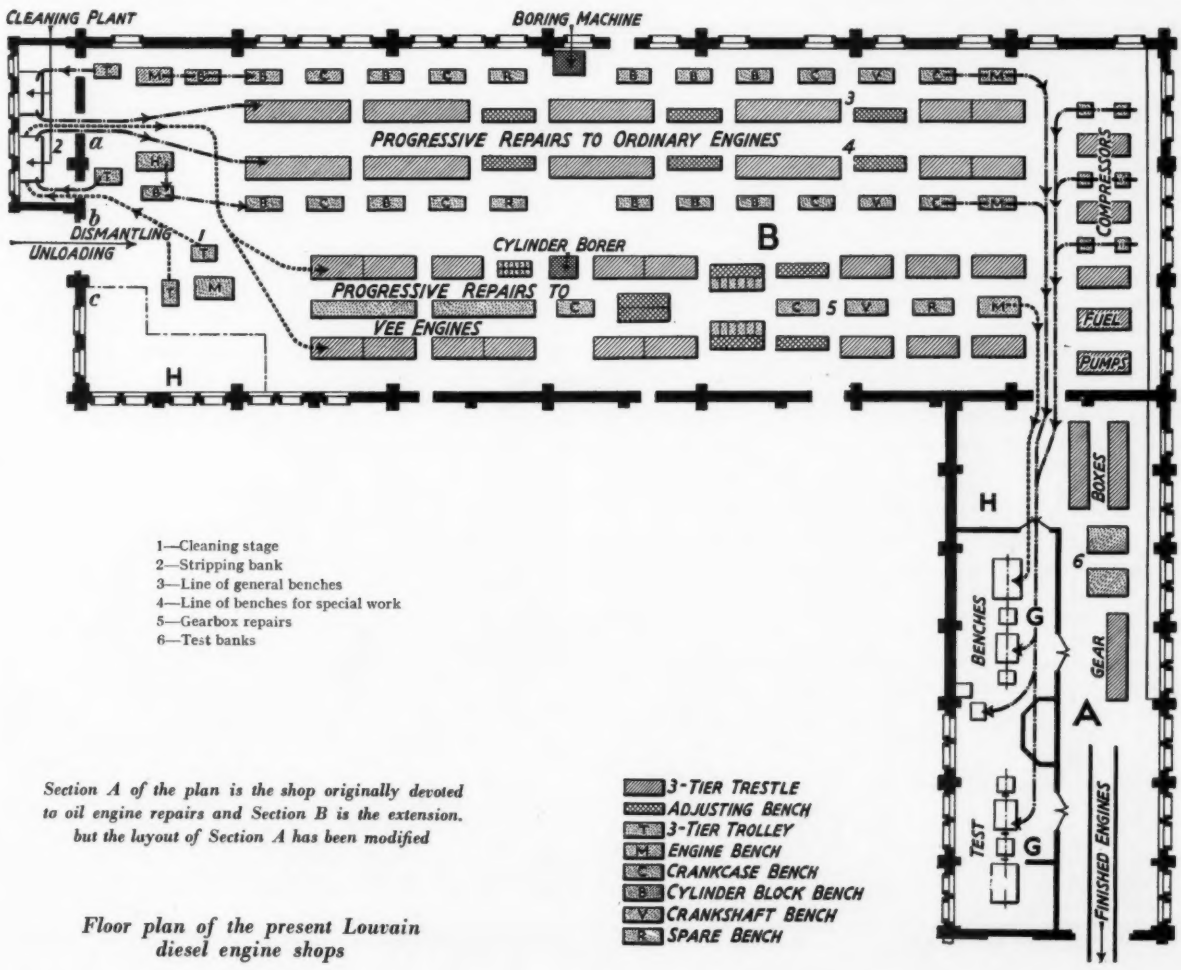
Maintenance and Repair

All cars and trains are given the usual daily inspection, in which the brake and sanding gear is examined; fuel, water and oil levels checked; heating boiler (if any) inspected; and a cursory examination made of the various control cables, the clutch, the traction motors or mechanical driving shafts, and the bogies. Every alternate day the oil filters in the single-unit cars are cleaned, the big ends examined through the light inspection covers in the crankcase walls, and the valve springs, rocker gear, and water-cooling circuit observed.

Normally, all types of cars and trains are held off one day a week for a more complete inspection and for any necessary maintenance work to be done. During these weekly visits to the depot the engine exterior is carefully examined, the filters cleaned, the water pump examined,

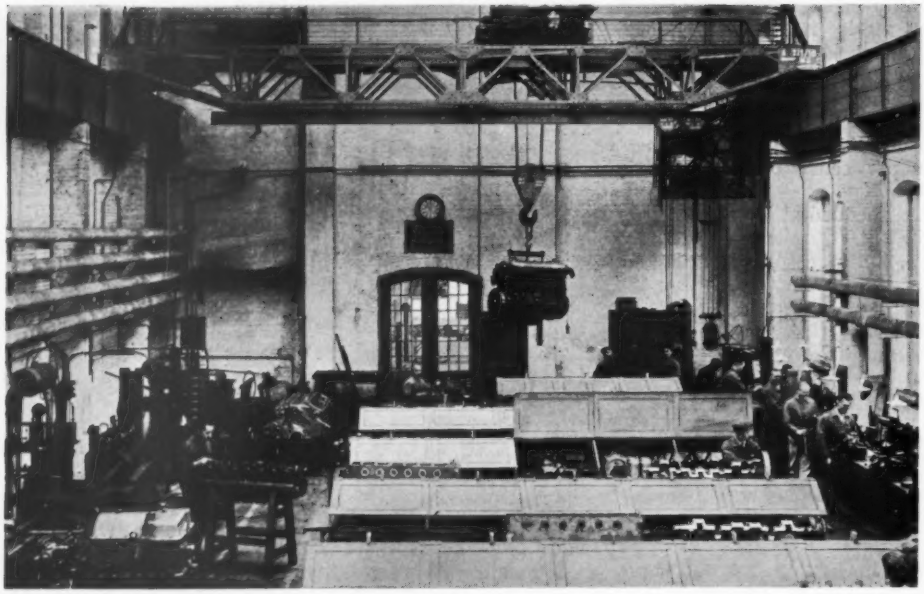
TABLE III.—PROPORTION OF DIESEL RAILCARS IN TRAFFIC, YEAR 1938, BELGIAN NATIONAL RAILWAYS

Depot	Type of car	No. of cars at depot	No. of cars in traffic	No. of cars in reserve	No. of cars under repair	Percentage of cars actually in traffic
Bruges	2-axle	3	2	1	—	66·6
Berchem	Bogie	6	4	1	1	66·6
Meirelbeke	Bogie	6	4	1	1	66·6
Liége	Bogie	1	1	—	—	100·0
Haine St. Pierre	Bogie	9	7	1	1	78·0
	2-axle	3	2	1	—	66·6
Brussels (Forest)	Twin-car	1	1	—	—	100·0
	Triple-car	8	5	2	1	62·5
Common reserve	Bogie	—	—	1	—	—



Section A of the plan is the shop originally devoted to oil engine repairs and Section B is the extension, but the layout of Section A has been modified

Floor plan of the present Louvain diesel engine shops



General view of a corner of the original workshop set aside for repairs to diesel railcar engines at Louvain works, Belgian National Railways. The engine suspended from the crane is one of the 175 b.h.p. Maybach units

the flexible couplings in the mechanical-transmission cars inspected, and the brake adjusted and any necessary details renewed. The oil levels in gearboxes and axle drives are checked; the auxiliaries examined, particularly the compressors; air filters cleaned; grease nipples refilled; electrical equipment inspected and the bearings of the generator and traction motors lubricated; and the lighting, dead-man equipment, batteries, and other details checked. At alternate weekly inspections the mechanical transmission details and the axleboxes of the single-unit cars are given a little more attention. The new Brossel cars are given a more complete examination of the engine and transmission every four weeks.

The labour required for maintenance is estimated at 26 man-hours a day plus 48 man-hours a week for periodical inspection and small repairs in the case of a triple-car train, and 18 and 22 man-hours respectively for a twin-car set. For single-unit cars the approximate figures are 12 man-hours a day plus 18 man-hours a week. Single-unit vehicles normally are withdrawn from service one day a week; for six days every six months for bogie overhaul and tyre returning, in addition to the usual maintenance work; and for 12 days every year for general overhaul. The inside of the body is repainted every two years and the outside every four years unless accidents or special circumstances shorten this time.

As regards the twin-car and triple-car trains, up to one complete day a week is allowed for maintenance and inspection; the set is out of service for six working days every three months in order to take up play in the boxes, to return the guiding wheel tyres when necessary, take up play in the brake gear, lightly overhaul the bogie, and to open up and adjust the engine in the central shops. Every six months the car is out of service for 24 working days, that is, after about 75,000 miles, for the overhaul of the bogies, tyre returning, engine overhaul, and body examination and repair. Painting of the interior and exterior is undertaken on the same basis as that of the single-unit cars. Overhaul of the mechanical portions of all diesel vehicles is centred at the Luttre workshops, and of the engines at the Louvain shops (see issue of this Supplement for June 12, 1936). Increasing experience and improved design is now enabling the time for heavy overhauls of the twin-car and triple-car trains to be reduced from 24 days to 16-18 days. The engines are overhauled at Louvain at the same time as the car is at Luttre.

TABLE IV.—OPERATING COSTS OF DIESEL RAILCARS AND TRAINS, YEAR 1938, BELGIAN NATIONAL RAILWAYS.(§)

Year placed in service	No. of railcars or trains	Type and arrangement	Class No.	B.H.P.	No. of seats	Distance covered in 1938, km.		Operating expenses in Belg. fr. per km. (exclusive of financial charges)								Total
								Traction cost				Depots		Works		
						Total	Per railcar	Driver's wages	Lubrication	Fuel	Overhead	Preparation	Maintenance	Overhauls	Modifications	
1930	3	Diesel-mech.; bogie	600	175	92	277,121	92,374	0·51	0·08	0·35	0·21	0·15	0·54	0·63	0·01	2·48
1932	1	Diesel-elect.; bogie	650	200	80	40,251	40,251	0·60	0·12	0·50	0·11	0·23	0·61	0·18	0·01	2·36
1933	14	Diesel-mech.; bogie	601	175	104	1,350,397	96,457	0·57	0·07	0·32	0·21	0·11	0·40	0·64	0·05	2·37
1934	1	Diesel-mech.; bogie	602	210	100	73,529	73,529	0·54	0·07	0·34	0·15	0·11	0·56	0·83	0·04	2·64
1934	1	Diesel-elect.; bogie..	651	210	100	57,964	57,964	0·52	0·09	0·40	0·16	0·11	0·69	0·95	—	2·92
1934	1	Diesel-elect.; twin ..	652	410	185	78,223	78,223	0·41	0·09	0·36	0·15	0·17	0·65	1·99	0·34	4·16
1934	1	Diesel-mech.; 2-axle	603	140	57	21,862	21,862	0·69	0·08	0·27	0·24	0·16	0·38	0·49	0·01	2·32
1934	5	Diesel-mech.; 2-axle	604	120	60	208,213	41,642	0·71	0·08	0·28	0·23	0·15	0·30	0·71	0·04	2·50
1935	1	Diesel-mech.; bogie	605	220	100	57,560	57,560	0·49	0·10	0·37	0·21	0·14	1·10	1·22	0·01	3·64
1936	1	Diesel-mech.; bogie	606	320	70	81,840	81,840	0·51	0·22	0·52	0·23	0·15	0·91	0·73	—	3·27
1936	1	Diesel-mech.; bogie	607	330‡	70	710	710	—	—	—	—	—	—	—	—	—
1936	3	Diesel-elect.; triple	653	820	229	450,000•	150,000•	0·39	0·20	0·78	0·24	0·21	1·88	2·20	0·01	5·91
1936	3	Diesel-elect.; triple	654	730	229	397,422	132,443	0·36	0·28	0·95	0·24	0·20	1·77	2·19	—	5·99
1936	1	Diesel-elect.; triple	655	900‖	229	Rebuilt with two 410 b.h.p. Maybach engines in place of two original Mercédès 450 b.h.p. engines										
1936	1	Diesel-elect.; triple	656	800†	229	45,104	45,104	0·31	0·39	1·15	0·26	0·22	3·29	3·11	0·01	8·74

• Approximate figures. † Now a twin-car train with one 400 b.h.p. engine. ‡ Now replaced by ex-450 b.h.p. engine from Type 655, derated. § This table does not include guard's wages. ‖ Now replaced by two engines aggregating 820 b.h.p. For fuller particulars of cars see p. 139, September 1 issue.

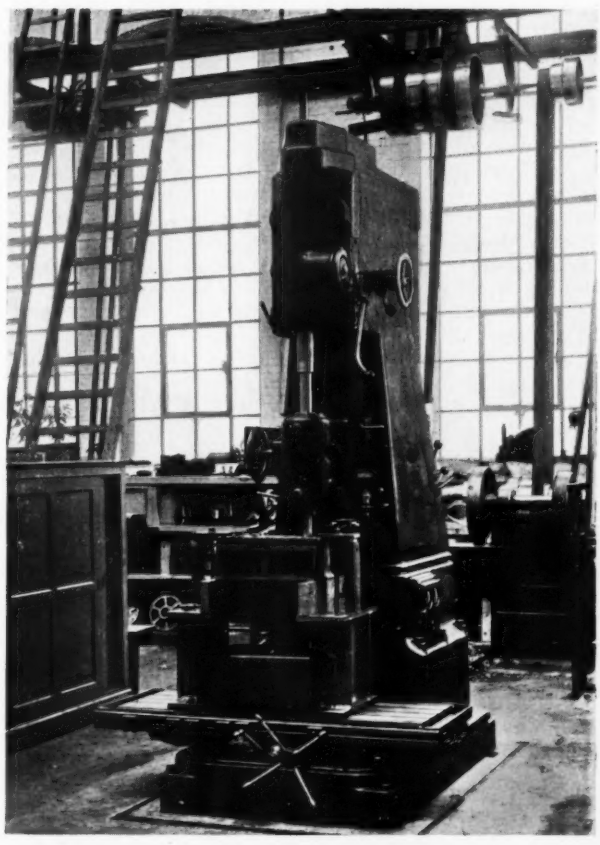
TABLE V.—OPERATING COSTS OF DIESEL, STEAM, AND ELECTRIC TRAINS, BELGIAN NATIONAL RAILWAYS

	Local railcar. Type 601. 175 b.h.p. diesel-mech., bogie 104 seats	Local steam train. One Type 16 loco. Three coaches 2nd and 3rd class† 146 seats	Triple-car diesel train. Type. 653–654 820 b.h.p. diesel-elect. 2nd and 3rd class 229 seats	Express steam *train bloc*. One Type 62 loco. Three coaches 2nd and 3rd class‡ 274 seats	Electric train Brussels-Antwerp. Four coaches 2nd and 3rd class 259 seats
Purchase price .. .. Belg. fr.	1,387,323	1,667,574	5,824,520*	2,736,385	5,028,617
Operating Expenses (Belg. fr. per km.) :—					
Drivers' wages	0·57	1·18	0·38	1·22	0·28
Fuel (or electric current)	0·35	1·76	0·94	2·48	2·16
Lubrication	0·08	0·04	0·25	0·07	0·02
Depot overheads	0·19	0·30	0·26	0·26	0·05
Miscellaneous	—	0·03	—	0·04	—
Maintenance and repair—					
Railcar, locomotive, or motor-coach	1·16	1·48	4·59	2·29	1·08
Carriages or trailers	—	0·52	—	1·08	0·63
Guard's and ticket collector's wages	0·80	0·80	0·80	0·80	0·80
Amortisation (railcar, loco, or electric train)	0·81	0·40	2·56	0·79	1·20
,, (ordinary coaches)	—	0·21	—	0·35	
Total (per km.)	3·96	6·72	9·78	9·38	6·22
Operating cost per seat-km. .. .. Belg. fr.	0·038	0·046	0·042	0·034	0·024
Life for amortisation charges :—					
A. Railcar motive equipment, locomotive, or electrical equipment .. .. years	10	33·3	10	33·3	33·3
A1. Mechanical portion of cars and electric trains, or train of ordinary coaches .. .. years	30	40	30	40	40
Distance corresponding to A .. .. km.	950,000	—	1,340,000	—	—
Distance corresponding to A1 .. .. km.	2,850,000	—	4,000,000	—	—

* The new 1,200 b.h.p. triple-car diesel trains cost 7,000,000 Belg. fr. each. † Old wooden carriages. ‡ Modern all-steel carriages.

Operating Costs

Including amortisation charges based on an engine life of 10 years and a mechanical portion life of 30 years, the operating costs of single-unit cars of 175 to 200 b.h.p. average 3·9 to 4·1 Belgian fr. per km., and of the twin-car and triple-car trains of 1934-36 builds from 9·75 to 10·0 Belgian fr. per km. These figures include maintenance and heavy overhaul, which items together form the greatest single item in the cost sheets. From Table V it will be seen that two of the lowest operating costs in the 200 b.h.p. class, exclusive of financial charges, are attained by the vehicles with electric transmission, but in neither case does the mileage approach that of the 175-210 b.h.p. diesel-mechanical railcars. It will also be observed from this table that in the year 1938 the highest average mileages of all the single-unit cars were made by the batches introduced in 1930 and 1933.



Krause precision cylinder borer at Louvain workshops

Although the single-unit railcars seating just over 100 passengers show a large saving per mile and per seat-mile compared with a three-coach steam-hauled train, the high initial and repair costs of multi-unit diesel trains in Belgium, where, apparently, the initial costs of express steam locomotives are by no means excessive, prevent the streamlined diesel trains from showing any improvement in operating cost over that of steam traction, particularly as depreciation of the motive power equipment is spread over only 10 years. Moreover, the short distances do not allow the diesel sets to make the mileages they could. The better design of the new twin-car and triple-car trains should enable a reduction to be made in the maintenance and repair charges, which in the 1936 trains amount to between 45 and 50 per cent. of the gross working cost. The working cost of one of the four-car Brussels—Antwerp 3,000-volt d.c. electric trains is considerably less than those of either steam or diesel trains if only those expenses connected with the train are considered, but to get the true cost suitable allowance must be made for the cost of the overhead equipment, substations, and the like.

DANISH DIESEL WITHDRAWALS.—Owing to shortage of imported oil fuel, the Lyntog services on the Danish State Railways have been cut drastically. The Englænderen between Copenhagen and Esbjerg has been suspended, and the other Lyntog services now terminate at Aalborg, Skive, and Esbjerg, instead of at Frederikshavn, Struer, and Ringkøbing as formerly. Moreover, the maximum permissible speed has been reduced from 120 to 100 km.p.h. (75 to 62 m.p.h.). The express diesel-worked Nordpilen service between the German frontier at Flensburg and Frederikshavn and Hirtshals in the north has been withdrawn. Reductions have also been made in the diesel railcar (and electric train) services in the Copenhagen area. During the fiscal year 1938-39, diesel and petrol railcars on the Danish State Railways ran 10,015,000 km., equivalent to 33 per cent. of the passenger train mileage.

PRODUCER-GAS RAILCARS IN FRANCE

The latest design, using wood fuel, is operated solo at speeds up to 75 m.p.h., and has third class passenger seats only

De Dietrich-Panhard 270 b.h.p. producer-gas railcar

THE largest railcars operated by producer gas up to the moment are three 70-ft. double-bogie vehicles built by De Dietrich for the Région de l'Ouest of the French National Railways, after experiments with lighter four-wheel cars in which a producer-gas plant and a modified engine were substituted for the original diesel engine. From a purely railway point of view the operation of all these vehicles has not been too satisfactory, and the S.N.C.F. was not proposing to build more cars of this type, but in view of the present situation it is not unlikely that further efforts will be made to run successfully railcars burning home-produced fuel.

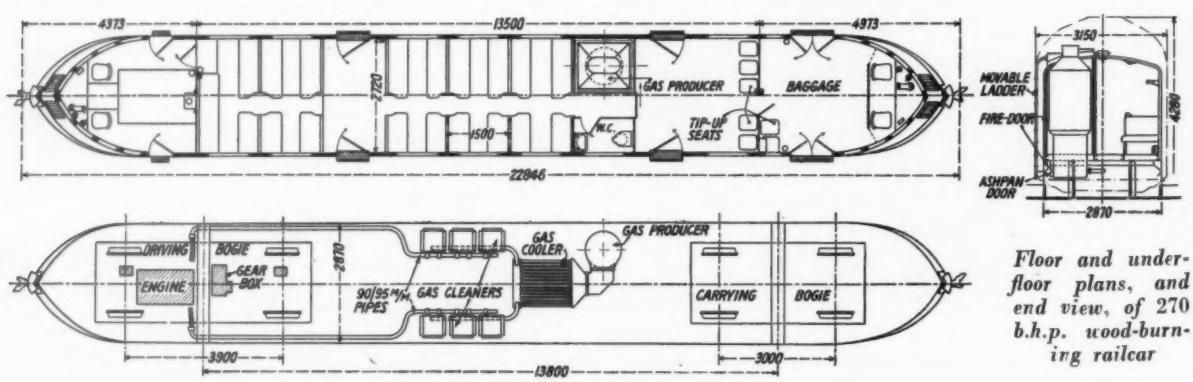
Wood Fuel

Charcoal or wood is used as the fuel and is burned in a vertical producer, mounted at one side near the centre of the car, and which is filled from a hole in the railcar roof, the fuel being carried in sacks up a light removable ladder. Old railway sleepers are a favourite fuel. This plant encroaches upon the capacity of the car to the extent of about six seats. The gas cleaners and coolers are carried below floor level and the fire can be inspected and the ashes cleared out through doors in the side panel of the car. A range of 300 miles is claimed with the fuel which can be charged into the producer or carried in sacks in the vehicle, and the consumption is 90 to 105 kg. per 100 km. (320 to 370 lb. per 100 miles).

A standard Panhard sleeve-valve 12-cylinder V petrol engine, suitably modified, forms the power unit, and in cylinders 140 mm. by 160 mm. with a piston-swept volume of 29·5 litres develops a maximum of 270 b.h.p. at 1,750 r.p.m., which is considerably less than when operating on petrol, when the top output, as in the Michelin cars, is 400 b.h.p. at 1,650 r.p.m. Aluminium alloy is used for the crankcase casting, and a similar material is used for the two cylinder blocks. Two special-steel sleeve valves are used in each cylinder barrel, those in each cylinder bank being driven by eccentrics on a shaft which takes the place of the normal camshaft.

The engine, along with a five-speed Mylius gearbox, is mounted directly on one bogie. Forced lubrication by a gear pump is fitted to the gearbox. The reversing gear is incorporated in the gearbox, and each axle of the bogie is driven through cardan shafts and a species of differential drive. The drive permits of operation of the railcar in either direction and there is a driving position at each end.

Steel construction of the normal De Dietrich type has been adopted for the chassis, which seats 54 passengers and has standing room for 45 on a tare weight of about 32 *tonnes*. A large entrance vestibule near one end, and 80 sq. ft. of baggage space, limit the number of seats. At 1,750 r.p.m. engine speed the maximum track speed in top gear is 120 km.p.h. (75 m.p.h.).



Floor and underfloor plans, and end view, of 270 b.h.p. wood-burning railcar

Light Railcar in Mexico

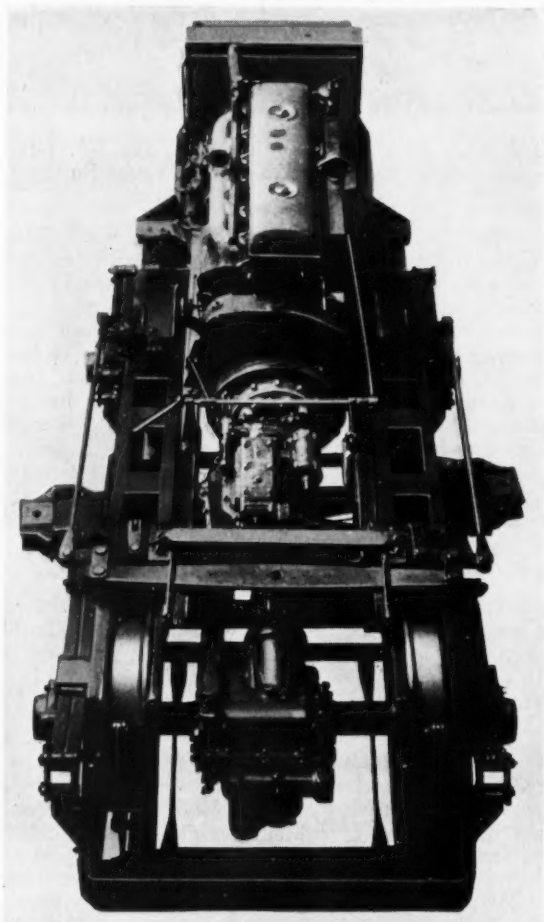
HITHERTO Mexican railways have used railcars rather sparingly, but there has been a tendency within the last 18 months or so to introduce light cars powered by oil engines. The latest vehicle is of the double-bogie diesel-mechanical type, and is used on the 3-ft. gauge Alvarado—Vera Cruz line, now owned by the Mexican Government, but built by Vera Cruz (Mexico) Railways Limited. The mechanical portion was built locally, but the two bogies and motive power equipment were supplied from Europe.

Due to the numerous sharp curves, the bogie wheelbase is limited to 6 ft. 6¾ in., and the bogies themselves have 27½-in. wheels and are pitched at only 26 ft. 3 in. centres. Over headstocks the car measures 46 ft., and within this length are embodied one driving position, an engine room, a small luggage room, two entrance and exit vestibules, 16 first class seats, 24 second class seats, and two lavatories. With supplies but without passengers or luggage the car weighs about 18 tons, and was designed for a top speed of 50 m.p.h. The doors at the vestibules are of the sliding pattern and are connected by rods to the bottom steps, which are raised and locked level with the sides when the doors are closed.

Power is provided by a six-cylinder engine developing 125 b.h.p. at 1,500 r.p.m., which, along with a Mylius four-speed gearbox, air compressor, and fan-cooled radiator, is carried on a subframe supported on the leading bogie at four points through the intermediary of rubber cushioning blocks. The gearbox has ratios of 5·35, 2·78, 1·575 and 1·0 to 1, and drives the inner axle of the bogie through double-reduction gears incorporating an air-operated reverse. Gear-changing and clutch movements are operated by means of compressed air. The power bogie complete weighs about 4·7 tons. Air brakes are used and actuate clasp rigging on all wheels. Welded steel plates and sections are used for the bogie frame.

Engine, gearbox and axle drive slope downwards towards the inner end of the bogie, and as the double reduction gear is between the axle and the inner headstock of the bogie, a little extra length has been obtained between the gearbox and the first axle-drive shaft. The sliding spline normally incorporated in the cardan shaft is in this design a part of the bevel pinion shaft, and is thus completely enclosed and well lubricated. The casing of the double-reduction axle drive is of the single-split type, and the lugs for the bolts are also used for the connection of the welded steel torque arm.

In order to ensure a low floor level and to reduce the tendency to tilt the bogie when starting or braking, the suspension has been constructed in an unusual manner. The flat, stepped bogie pivot is beneath the gearbox at the bottom of the bogie frame structure, and is carried by a bolster which extends transversely through the side frames. The outer ends of the bolster carry semi-elliptic springs which support the car body through shackles. Bolster guide plates extend downwards from the underframe, and the car body can swing sideways on the shackles. Side friction blocks are provided between the bolster and the main longitudinals of the bogie frame, but the surfaces come into contact only with oscillations. In the central position there is a play of one millimetre.



Sky view of bogie carrying engine and transmission, Mexican railcar

Publication Received

The Oil Engine Manual: By D. S. D. Williams, A.M.I.A.E., and J. Millar Smith, B.Sc. London: The English Universities Press Limited, Warwick Square, E.C.4. Published for Temple Press Limited. 8¾ in. × 5½ in. × 1 in. 368 pp. and index. Illustrated. Price 5s. net.—Approximately 75 per cent. of this book is simply descriptive, comprising illustrations and short notes on the features of English—and a few foreign—oil engines for power station, industrial, tractor, road and rail transport, and aviation purposes. A book giving really detailed descriptions of the best-known models might be of some use to numerous engineers, but well over 200 pages of stereotyped 300/500-word descriptions telling readers that aluminium-alloy pistons run in iron liners are tiresome, particularly when one knows that the authors have the ability to turn out good, original work. The railway oil engine section comprises 36 pages, and the text deals only with English engines. The first 86 pages of the book are devoted to the working principles, fuel and combustion equipment and phenomena, pressure-charging, lubrication, and maintenance. Herein lies the cream, for the authors write clearly and concisely while giving information in an interesting manner. One suspects they found much more pleasure in writing these sections than in compiling the remaining three-quarters of the book. Both line and half-tone blocks are well reproduced; many of them, along with some of the text, have been reused from the pages of the *Commercial Motor* and the *Oil Engine*, with the second of which journals the authors are associated editorially.

NOTES AND NEWS

Soviet Railcars.—Some two-car, close-coupled internal-combustion-engined train sets have just been set to work on the 5-ft. gauge lines in the U.S.S.R., and are being tested in a variety of services.

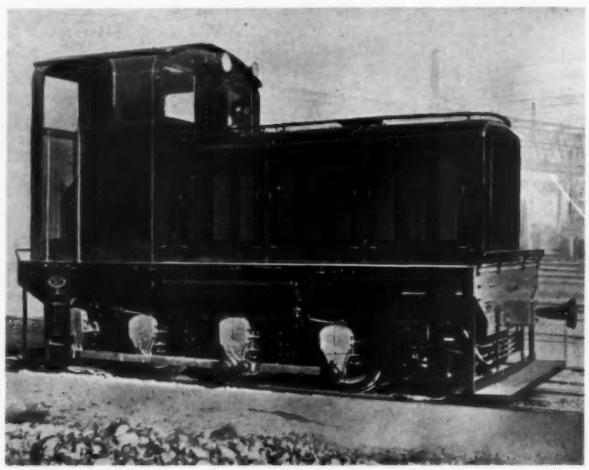
Danish Railcar Sale.—The last remaining section of the narrow-gauge Haderslev County Railways—from Haderslev to Toftlund—was closed on June 23, and the two diesel-electric railcars and one diesel shunting tractor have been sold to the Bornholm Railways for 100,000 kr., a very cheap price considering the stock was built only five years ago.

Lyntog Rebuilt.—The three-coach Lyntog, which was gutted by fire just before Christmas, has been rebuilt as a four-coach train and has been in service again since July 1. Opportunity has been taken to alter the bogie springing to conform with that on the other four-coach trains, and the air brake system has also been converted in the same manner. On the three-coach Lyntog there was one brake cylinder for each brake shoe, while the four-coach trains have the more normal arrangement of one cylinder per bogie. These two changes will also be made on the three remaining three-coach trains. In the rebuilt train the two power bogies, the two traction bogies and the two streamlined noses of the end-coach bodies are the original ones, while the remainder of the trains is entirely new.

Diesels for Mines.—Experience in the Lens coalfield in France has shown that to handle underground a traffic of 2,400 tons a day between two specific points, eleven diesel tractors were required, at an initial cost of 880,000 fr., whereas the same number of electric battery loco-tractors with spare batteries and charging plant cost 2,472,000 fr. Of the eleven diesel tractors three are held as spare; those used are of 20 h.p., and have C.L.M. two-stroke opposed-piston engines. The fuel, repair and labour charges do not differ greatly between the two types. On the other hand, in the Courrières mines the repair costs of the diesel loco-tractors are 0·12 fr. per km. less than with electric battery locomotives. At the Aniche mines the operating cost of the electric battery locomotives is 0·88 fr. per *tonne*-km., of which 50 per cent. is due to amortisation charges; the diesel locomotives operate at a cost of 0·60 fr. per *tonne*-km., of which 58 per cent. is due to labour charges.

American News.—The Seaboard Air Line has ordered two further 2,000-b.h.p. Electro-Motive diesel locomotives and two seven-car stainless steel Budd trains for express passenger service. The Manitou & Pike's Peak Railway, which rises to a height of 14,110 ft., has taken delivery of a diesel-electric rack locomotive from the General Electric Company. There are three power groups, each set to give about 100 b.h.p. at the maximum altitude, compared with about 160 b.h.p. at the bottom of the line, which is nearly 2,000 ft. high. A new 70-ton, 400-b.h.p. diesel-hydraulic locomotive is undergoing tests in yard service in the States. During the year 1933, 110 diesel locomotives were placed in service by 30 American railroads or operating companies, making a total of 499 diesel units operated by 96 railroads or companies at the end of that year. A total of 92 diesel locomotives was on order in the U.S.A. in April last.

New Zealand Activities.—The newly-opened 73-mile line in North Island between Napier and Wairoa and Waikokopu, running through the Hawke's Bay country, is being operated as regards passenger traffic by some of the double-bogie Leyland-engined diesel-hydraulic railcars built last year (see issue of this Supplement for September 2, 1938). A through railcar service from this line to Wellington is run every week-end. The ten 275 b.h.p. diesel-electric railcars ordered from the Vulcan Foundry



100 b.h.p. 15-ton Drewry shunter on the 3-ft. 6-in. gauge lines of the New Zealand Government Railways

are to be allocated chiefly to services in South Island, including Christchurch to Parnassus, with extended running probably to Hundalee (on the Parnassus-Picton extension of the South Island main line now under construction); between Christchurch and the west coast; between Christchurch and Timaru; and on the Oamaru-Dunedin, the Otago central, Invercargill-Lumsden, Invercargill-Gore-Lumsden, and Invercargill-Bluff lines. A number of 100 b.h.p. Gardner-engined Drewry shunting locomotives are now giving efficient service on the Government Railways. One of these, a 15-ton 0-6-0 locomotive, is illustrated on this page; it has a three-speed gearbox giving track speeds of 6·3, 9·6 and 15 m.p.h., and under favourable conditions can haul a 500-ton trailing load on the lowest gear step and 200 tons on the top gear.

Australian Diesels.—The South Australian Railways are now operating five railcars with 204-b.h.p. Gardner 8L3 engines, four with 102-b.h.p. 6LW engines, and one with an 85-b.h.p. 5LW engine. The Victorian Railways have one railcar with a 6LW Gardner engine and four with 68-b.h.p. 4LW engines.

D.E.U.A. Programme.—The committee of the Diesel Engine Users Association has decided that every effort should be made to carry on the work of the Association as usual, in spite of war conditions. Until further notice the meetings will take place in accordance with the programme already published, except that the time of the meetings, at Caxton Hall, Caxton Street, Westminster, S.W.1, on the advertised dates, will be at 2.30 p.m., instead of 5 p.m. The first meeting is on Thursday, October 12, when a Symposium on Running Gear for Diesel Engines will be submitted for discussion.

Diesel Railway Traction

Railcars for Ceylon

NO better tribute can be given to the efficient operation of any motive power than a repeat order, and the contract placed with the English Electric Co. Ltd. by the Crown Agents for the Colonies for eight diesel-electric railcars for the Ceylon Government Railways may be taken as indicative of the good service given by the existing four-car trains of the same make—additional proof to that given by Mr. H. W. Freer, the Mechanical Engineer of the railway, in his recent paper, abstracted in our issue of September 1 last. The new cars are to be double-bogie units fitted with multiple-unit control, but normally will operate solo. Each car is to be powered by an English Electric six-cylinder engine set to give 200 b.h.p. at 1,500 r.p.m., and this, together with the attached main generator, the control equipment and the traction motors are to be the same as those fitted in each end of the existing four-car diesel trains. Third class accommodation only is being provided, but the 80 seats will be of a comfortable type, and the passenger saloons are to be well ventilated. The body framing is to be of steel, completely welded up on the principles evolved at the Dick Kerr works, and the bogies also will have welded steel frames. Fully loaded, the cars will weigh about 40 tons, and thus will have a greater b.h.p. per ton than have the four-car sets. This increase is deliberate, as it is intended to increase the speed and intensity of the services. Nominally, the top speed over the 5 ft. 6 in. gauge tracks is to be 50 to 55 m.p.h.

Railcar Success in New Zealand

IN his report for the year ending March 31 last, Mr. D. G. Sullivan, Minister of Railways in the New Zealand Government, said that the successful operation of railcars of types evolved by New Zealand engineers and built [partly] by New Zealand craftsmen had been one of the most notable developments in the modern service offered by the department. It was helping to turn the tide of traffic back to the rail. So marked, indeed, had been its progress that the full effect of railcar evolution would be difficult to predict; but he could safely say, from experience with them up to the present, that in their ultimate development, whether singly or as multiple-unit trains, they would prove invaluable as an aid to the development of the more backward portions of the country in providing transport of a frequency, comfort, speed, and convenience not conceivable by any other practicable means in the undeveloped territories they would serve.

For the year just ended the nine cars already in use (seven on the Wairarapa route, North Island, and two on the Midland route, South Island) ran nearly 400,000 miles and recorded a passenger-mileage of over 8,000,000. Already the new, larger, and heavier type [the 260 b.h.p. double-bogie Leyland-engined cars described in the issue of this Supplement for September 2, 1938], had been running successfully for several months on the Wellington—New Plymouth route, and provided a very attractive service supplementary to that of the mail trains. A complete service of these standard railcars had also been provided to work a full passenger service on the new Napier—Wairoa line, which was opened on July 1. Even in the first weeks of operation the popularity of this new form of transport in the newly-opened territory had been strongly demonstrated and was more than likely to continue. A total of 16 double-bogie cars (some of which were being imported) would be running in various parts of the Dominion during the present year. The response and reactions to the operation of those already in traffic had been entirely satisfactory and were a tangible guide to the programme for construction and distribution of units of this new arm of the railway service in its work of providing suitable transport to aid in further national development, and in improving still more the amenities of Dominion travel.

Electric Supply for Auxiliaries

SUPPLY of current to the auxiliary services and for charging the starting and lighting batteries in diesel-electric railcars and locomotives is provided in a variety of ways—sometimes by current direct from an overhung auxiliary generator on the main shaft, and in some large locomotives by the installation of a separate small oil engine and generator. In certain examples where current is furnished primarily from the auxiliary generator, a converter set is included to supply all those services where constant voltage is a necessity. For instance, in the Dutch triple-car 820 b.h.p. trains there is a Brown Boveri 15 kW motor-generator converting set in differential connection. The motor and generator are connected in series in a special manner and are connected up to the voltage of the overhung auxiliary generator, which varies between 110 and 165 volts. On the secondary side of the set, running at almost constant speed, a constant tension of 100 volts is available for the lighting circuit. In addition to this, a.c. at about 70 volts is tapped from the generator and stepped down in a transformer to a lower voltage for use in the searchlights at each end of the train. Certain single-unit cars with one 410 b.h.p. main engine-generator equipment have a quick-acting regulator to keep the tension of the auxiliary generator supply constant at 110 volts, and battery charging is carried out by a converter set in booster connection. Another method, using a converter set, is to connect the motor of that set to the terminals of the auxiliary generator, and use the converter to supply the lighting current in conjunction with a 24-volt battery. Again, there are a few diesel-electric railcars which have no auxiliary generator, and the converter set is connected to the variable voltage of the main generator, which may fluctuate between 150 and 600 volts. The generator of the voltage-converter set delivers current at a tension of 26-30 volts to charge the starting battery and to supply the control and lighting circuits. A quick-acting voltage regulator regulates the generator voltage by influencing the generator field.

INCREASED SCHEDULE SPEEDS BY THE USE OF RAILCARS

Further discussions on the subject of improvement of services by railcars at a meeting of the Permanent Commission of the International Railway Congress Association, held in Brussels last July

DURING the meeting it was suggested that in certain countries the use of single or double railcars had often given rise to difficulties as regards meeting peak traffic, but the experience of railways such as those of the Netherlands, on which three-car sets are coupled together up to a maximum of 12 vehicles, seems to indicate that the difficulties can be nullified except in special cases. On the German State Railway four-wheel railcars are used up to a maximum train capacity (railcar plus trailer) of 100 seats. In the case of double-bogie railcars the maximum capacity is about 500 seats, such a train comprising two railcars and four trailers. As far as the *schnelltriebwagen* are concerned, the present practice limits the coupling to two triple sets. In times of traffic requiring more accommodation, steam trains are used, but each time a careful investigation of the case is made. The German reporter emphasised the success which had attended the efforts to couple up railcars with different types of transmission, the whole set being driven by one man. While the Netherlands Railways found that they could deal with peak traffic by coupling up three or four triple-car sets, it meant that no reserve vehicles were on hand on those days, and when peak periods were known in advance arrangements were made to have the minimum possible number of sets under repair.

Importance of Multiple-Unit Working

The chairman of the session, M. Le Bésnerais, General Manager of the French National Railways, said that although no general solution appeared to have been found for dealing with peak traffic by railcars, his view was that it was advantageous to buy railcars suitable for coupling in multiple-unit, so that they could be used for services over a great many sections and be grouped on certain lines at definite peak periods. The use of railcars in each particular case had certain economic limits which were mostly dictated by the magnitude of the traffic peaks. M. Demaret, of the Belgian National Railways, said that on his system the railcars and twin- and triple-car trains had no multiple-unit equipment fitted and steam traction was always used for regular traffic peaks. Although all modern railcars in Italy are arranged for coupling in multiple-unit, Sr. Cuttica, of the Italian State Railways, said that most traffic peaks of great magnitude were not dealt with by railcars. In Italy the railcar services as a rule radiated from given centres, and as steam locomotives for goods traffic were still in service at these centres they were used to haul the augmented passenger trains at times of peak, the trains being made up of ordinary passenger stock. Apparently no great trouble had been experienced in working light passenger trains at fairly high speeds with small wheeled locomotives.

Agreement on Financial Economy

The Permanent Commission agreed with the reporter's conclusions: (*a*) that the operating cost per mile of a four-wheel railcar is about 30 per cent. of that of a three-coach or four-coach steam train on secondary lines; (*b*) that the operating cost per mile of a bogie railcar of light design and working without a trailer is about 60 per cent. of that of a steam train on secondary lines; (*c*) that the operating cost per mile of a bogie car hauling a trailer is about 75 per cent. of that of a steam train on secondary lines; and (*d*) that the operating cost per mile of a high-speed railcar or railcar train is 50 to 100 per cent. of that of a four-coach express steam train.

As regards conclusion (*a*) it was pointed out that although a four-wheel railcar had not the seating capacity of a three- or four-coach steam train, it was by no means uncommon for such a steam train to have very few of its seats occupied. As regards conclusion (*c*) the reporter emphasised that his relative costs were based on a railcar with trailer giving 150 seats and a steam train with 200 seats, but one of the members pointed out that bogie cars with a trailer frequently have a capacity of up to 240 seats. Emphasis was also laid on the fact that the operating costs per mile of high-speed cars varied very greatly from one administration to another, according to the type of stock and the operating conditions. On a mileage basis, it was usually less than that of a four-car steam train, but was not always less if a seat basis was taken.

Amortisation

Although many railcars are now amortised on the basis of about 10 years for the motive power equipment and 20 to 33 years for the carriage portion, it seemed to be the feeling of the Permanent Commission that the charges ought to be spread over a period of at least 20 years, and with an effective annual mileage of 87,000. Although the principle of buying a railcar as cheaply as possible had often been advocated, it seemed to be much better to have a railcar with a longer life, although costing more. On the other hand, the expected life should not be so long that the car would become obsolete. Certain railways had the intention of building railcars which would not last for longer than 25 years, on account of the rapid progress being made in design and construction. Experience on the Hungarian State Railways had shown that the life of the engine did not much exceed ten years, whereas the coach portion might last 35 years. On the Reichsbahn, the figure of 30 years for the life of ordinary passenger rolling stock had been reduced to 25 years for the coach portion of the railcars, in order to take into account the greater wear and tear. At the moment, a period of ten years had been taken for the life of the power plant, but this was not considered as final.

The life of the engine seemed to depend a good deal on the system of repair and renewal. It is conceivable that if present methods of steam locomotive maintenance and repair were followed, the life of the engine could be 40 to 50 years. A view akin to this seemed to be prevalent in Italy, where the State Railways insisted upon heavy repairs being carried out so thoroughly that the life of the engine would appreciably exceed 10 years. Certain engines in that country had run 155,000 miles between heavy repairs. In France, up to the present time the engine heavy overhauls had been given every 75,000 miles, and progress had been made towards raising this figure to about 112,000 and in some cases to 140,000 miles. The Reichsbahn was aiming at a mileage of 125,000 between heavy repairs to the engines, but this had not yet been achieved with the high-power type.

As regards maintenance costs on the mileage basis, experience on the Reichsbahn indicated that when the average speed of the trains was increased, the rolling stock

maintenance cost decreased, whereas so far as locomotive costs were concerned they increased with the speed. On the other hand, railways in other countries had had exactly the opposite experience, and seemed to hold the opinion that these costs were more or less constant, on the condition that the train load was reduced with increasing speed. The maintenance cost of the carriage portion of railcars in general was higher than that of ordinary rolling stock, partly because of engine and transmission vibration and stresses, and often because of the higher speed at which the railcars ran.

Garaging

The great length of three-car to five-car diesel trains did not appear to have given rise to any garaging difficulties. For example, on the Netherlands Railways the present three-car sets were kept in the open, the air filter-

One of the Ganz cars which operate short-distance interurban services on the North Western Railway of India

ing and heating equipment, as well as the water cooling arrangements, being so designed that they could stand up to low temperature. Similar garaging procedure is to be followed with the five-car sets now under construction. The German State Railway began by garaging the *schnelltriebwagen* under cover, but as the number increased this practice was given up, and after the sets had been inspected and cleaned they were garaged in the open both summer and winter; but to meet the rigorous winter climate in certain parts it had been necessary to take additional precautions; for example, the installation of heating equipment which could work for four hours without attention. If the sets were to be garaged in the open for a longer period the heating equipment had to be checked over every four hours.

Further Conclusions

The following are some of the more important conclusions come to by the Permanent Commission, in addition to the four already mentioned:—

Experience has shown that there exists a limit beyond which railcars are no longer suitable economically for periods of peak traffic. This limit is higher when the railcar units can be coupled together. In practice, for periods of exceptionally heavy traffic, it is necessary to utilise steam trains at least in some services. The use of steam traction in cases of this kind does not unduly increase costs if goods locomotives suitable for working passenger services can be used during the peaks. The managements using multiple-unit railcars, especially triple or quadruple railcars with second or third class compartments (Holland, Denmark) or second class only (Germany, for express sets) find no difficulty in dealing with peak traffic, by coupling their multi-car sets together to form sets of eight vehicles (Denmark), nine vehicles (Germany), or even 12 vehicles (Holland), so that the capacity corresponds exactly to the traffic offering.

Generally speaking, the cost per seat available in a railcar is higher than that of the corresponding seat in a steam train. In Holland, however, it has been found that the cost per seat available in the triples, second and third class, is only about 90 per cent. of that per seat in the steam trains; three other administrations have reported similar findings in the case of other kinds of equipment.

The cost per railcar-mile per seat offered is high, on the one hand because of the maintenance costs, and on the other hand because of the amortisation charges. Maintenance costs are considerably reduced when the railway owns a relatively large stock of railcars, strictly standardised from the mechanical point of view. The amortisation charges can be reduced when the railcars are so built as to have a long life and give a very high annual mileage. Experience would seem to show that apart from the engine portion of the car, the amortisation of modern railcars of robust type ought to be calculated on a period of at least 20 years, and an effective annual mileage of 87,000, corresponding to a daily mileage of 250 per railcar, of the whole stock.

KOELA PRODUCER-GAS PLANT.—Manufacture of this plant, which uses anthracite or low-temperature coke, has been taken over along with the patents by the Brush Electrical Engineering Co. Ltd., of Loughborough; in future the plant will be known as the Brush-Koela. Arrangements for the sale and distribution are now being made by Brush.

DIESEL-STEAM LOCOMOTIVE.—What appears to be a resuscitation of the Kitson-Still locomotive is said to have been completed by the Voroshilovgrad works in the U.S.S.R. Intended for passenger service, this machine is said to have a maximum capacity of 3,500 h.p. and a top track speed of 75 m.p.h., but the longest run without refuelling is only 435 miles.

XUM

TWO-STROKE OIL ENGINES

Some notes on the design and performance of the models available for railway work

SURPRISE is often felt at the small application of two-stroke engines to traction duties, particularly in view of the requirements of high power per unit of weight. Despite twice the number of impulses at any given speed, the two-stroke of equal cylinder dimensions and speed does not give anything like twice the power of a four-stroke. The incomplete scavenging which is possible in the short time available prevents the attainment of equal m.e.p.'s and moreover prevents the general run of two-strokes turning at the rotational speeds considered quite normal for railcar four-strokes. Since the abolition of the piston valve controlling the exhaust, and its replacement by a single poppet valve in the head, the speed of the Burmeister & Wain type of railway two-stroke has increased to 1,250 r.p.m. as a maximum, but the Winton engine, most used of all, is still limited to 750 r.p.m. The Junkers opposed-piston type of two-stroke, on the other hand, has been operated for years at 1,500 r.p.m., and the newest models have a power-weight ratio even better than pressure-charged four-strokes.

The new Fairbanks-Morse opposed-piston engine just introduced into railway service in the States, has lower rotational and piston speeds than any of the makes mentioned above, but has a surprisingly high m.e.p., akin to what is found in the Junkers opposed-piston aircraft engines.

Inverted V Engine

A railway forerunner of the opposed-piston type was the Knudsen inverted-vee 12-cylinder two-stroke engine installed by Baldwin in a heavy shunting locomotive in 1925. Ostensibly of 1,000 b.h.p., this engine never developed more than about 750 b.h.p. at 500 r.p.m. even after much experiment, and not a little of its operation was characterised by an exhaust the colour of coal, which began at generator outputs of 320 h.p. and engine powers of about 525 b.h.p. Indicated outputs up to a little over 1,100 h.p. were recorded, but the main generator output at this power did not exceed 650 h.p. The compression ratio of this engine was less than 12 to 1. The fuel consumption was very high, being equivalent to 0·7 lb. per b.h.p. hr. at 700 b.h.p. and 0·455 lb. at 500 b.h.p. There were no poppet valves in this engine, the scavenging air and exhaust gases coming in and going out through circumferential ports in the cylinder barrel, which were controlled by the piston; the inlet ports were cut in one cylinder bank and the exhaust ports in the other, and the exhaust cranks had an advance of 9 deg.

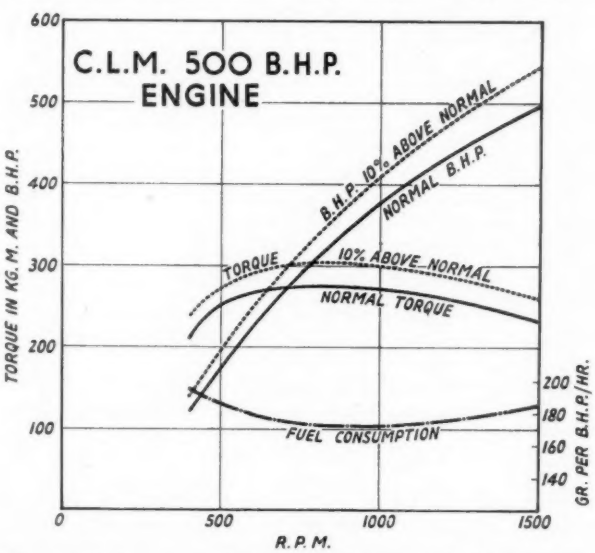
Two-Stroke Characteristics

All the ordinary railway two-strokes—which in types are limited to the Winton and Burmeister & Wain—have uniflow scavenging, with inlet ports round the liner and an exhaust valve in the cylinder head, and are thus in contrast to the great majority of two-strokes for industrial and marine purposes. It is this attribute of the opposed-piston engine which has enabled the speed and output of the normal two-stroke to be increased during recent years. As in two-stroke engines the inertia forces are cushioned by the compression, high piston speeds can be used in conjunction with moderate rotational speeds and with cast iron pistons; for example the eight-cylinder 360 b.h.p. Harlandic engine running at 1,200 r.p.m. has a piston speed of 1,735 ft. per min. Nevertheless, high piston speed is not necessarily a good criterion of two-stroke performance, for a lengthening of the stroke may not produce an increased proportion of the stroke for compression and expansion, and it is easier to obtain a good performance at a high piston speed if the stroke : bore ratio is high than if it is low, and in the Harland & Wolff engines it is very high, up to a maximum of 1·66 : 1 in the 500 b.h.p. locomotive type of engine running at a maximum of 800 r.p.m. On the other hand, the Winton engine has a low stroke-to-bore ratio, *viz.*, 1·25 to 1, and in the latest 12-cylinder 1,000 b.h.p. engine only 1·18 to 1. The piston speed is low, 1,250 ft. per min., but nevertheless aluminium alloy pistons are used. Some trouble was experienced with the original alloy, and on the Burlington Zephyr trains the heat-treatment of the alloy and the design of the piston were changed somewhat, in order to get over the excessive heat which resulted in over-expansion and seizing and scoring of the piston and liner.

Piston and Valve Problems

Heating of the piston crown and the underside of the cylinder head is the weakest point in the practical operation of the two-stroke, because combustion occurs once every revolution. The effects are particularly severe in the opposed-piston type, for which steel plates have had to be fixed over the crown of the aluminium alloy pistons. Similarly, the exhaust valve head in the railway types is subjected to combustion heat once every revolution, and, as it is on its seat about three-quarters of the whole time, compared with, say, two-thirds in a four-stroke, its ability to withstand heat is a problem, whereas in the four-stroke the exhaust valve is no trouble at all, and indeed in certain designs of recent years has even been reduced in size to make room for a bigger inlet valve.

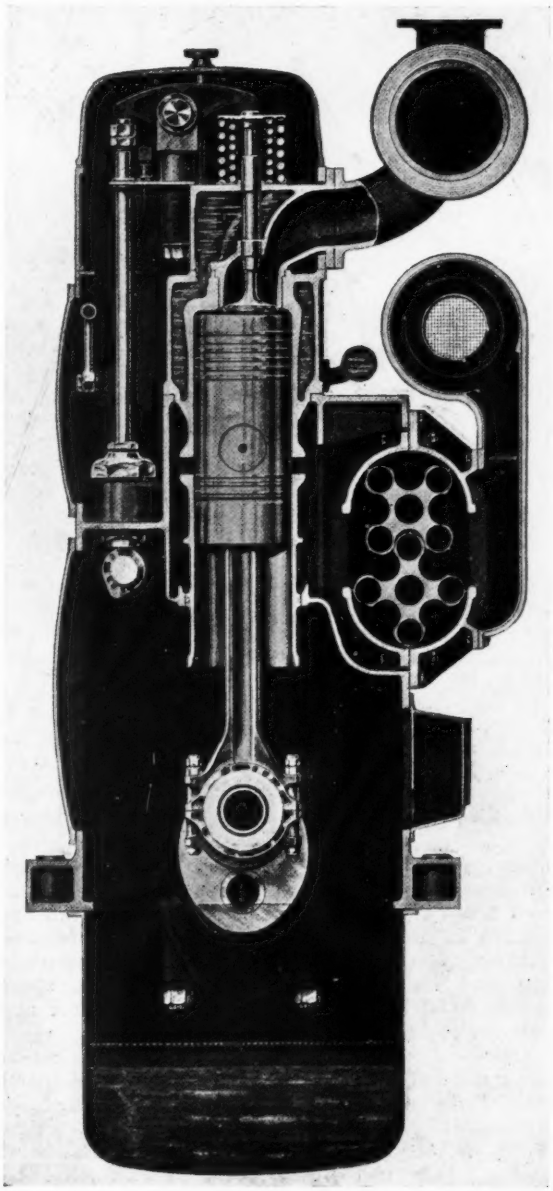
Apparently the Fairbanks-Morse 940 b.h.p. opposed piston engine has cast iron pistons without any steel crown plates, despite the high m.e.p. and temperatures, but it is understood to have a slight degree of supercharge,



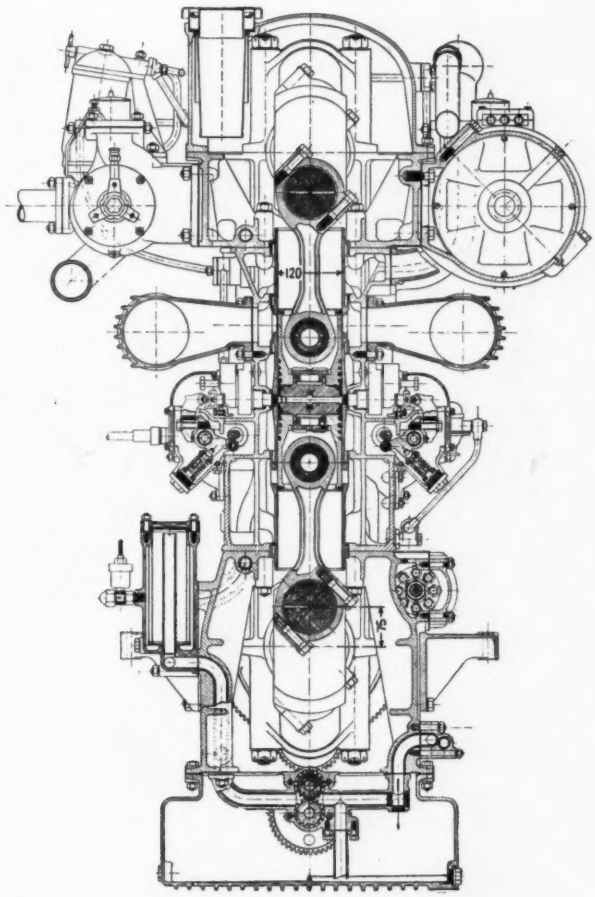
Characteristic curves of eight-cylinder opposed-piston engine

and possibly the Roots scavenging blower delivers a good deal of excess air which cools the piston heads, and, further, the undersides of the crowns are oil-cooled. The pistons, owing to the control of the circumferential ports, are much longer than are found in four-stroke engines. The Harlandic engine, for example, has a length to bore ratio of 2·4 to 1, but in the Winton design the ratio is only 1·4 to 1; in the opposed-piston Junkers engine it is 1·36 to 1.

Mechanical considerations also may be a limiting factor, or at least a problematic one, in the operation of two-strokes, as the cylinder pressure is always positive, that is, it acts uniformly in a downward direction; the pressure on the bearings has similar characteristics, and thus lubrication needs specialised attention. If either air or exhaust poppet valves on the heads are used, the inertia stresses in the rocker and valve gear are slightly increased, as the valves must be opened and closed at a somewhat higher velocity than in the four-stroke, and there are twice as many movements per cycle.



Cross-section through Harlandic uniflow-scavenge engine



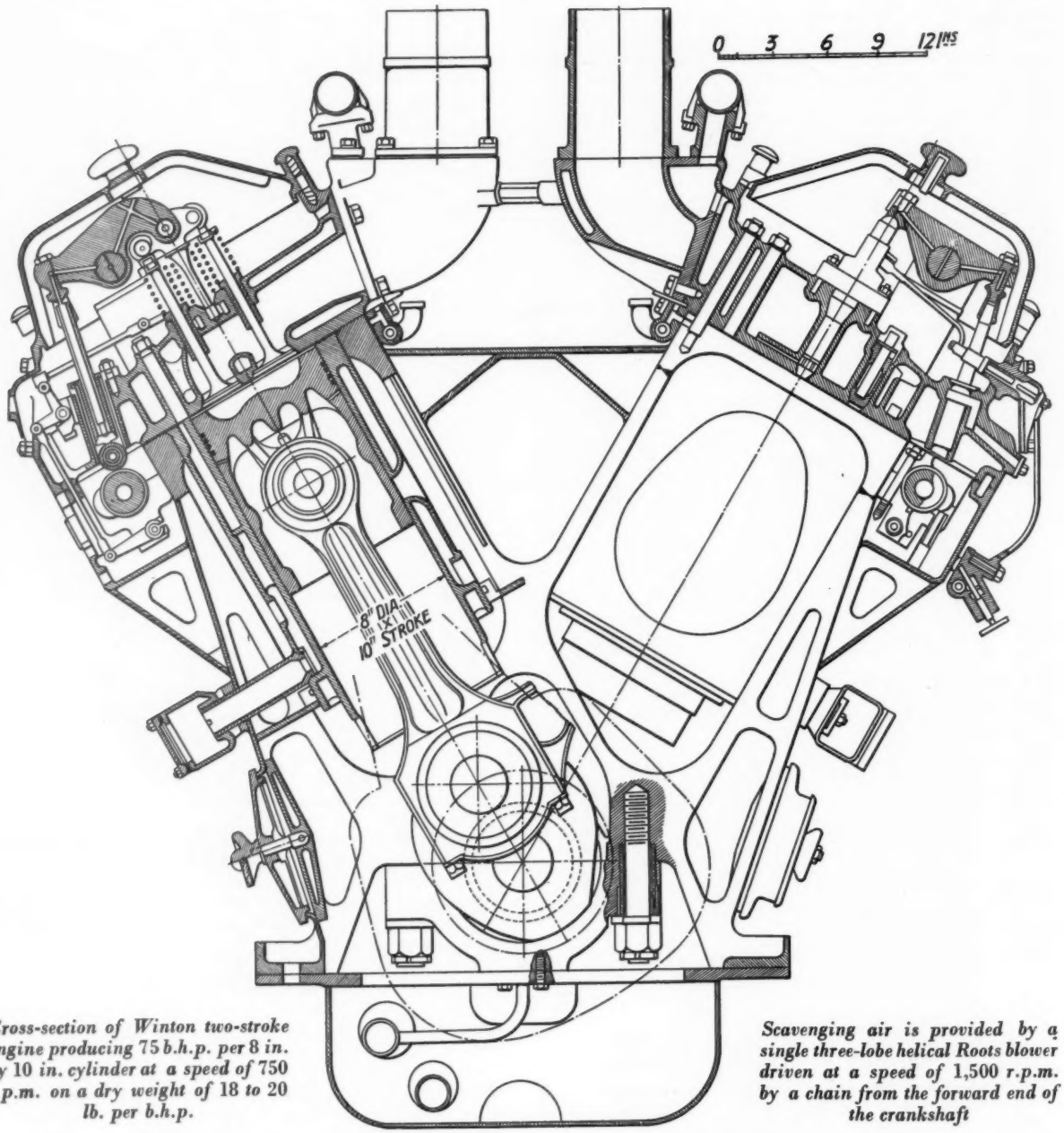
Cross-section through C.L.M. Junkers 550 b.h.p. opposed-piston engine which runs at 1,500 r.p.m.

C.L.M. Engine Tests

The design and construction of the 250 b.h.p. and 500 b.h.p. C.I.M.-Junkers opposed-piston engines, as applied to French railcars, were described in the issue of this Supplement for October 1, 1937. Subjected to the standard 72-hr. test of the French National Railways, the 4DV120 model showed little difference in its characteristics at 275 b.h.p. compared with its more normal limit of 250 b.h.p. at 1,500 r.p.m. The cooling water temperature remained unchanged; the specific fuel consumption rose by less than one per cent. and the scavenging pressure by 13 per cent.; but the exhaust temperature rose by 13-14 per cent.

Using fuel of 10,550 cal. heat content and a specific gravity of 0·832 at 19° C., the engine ran non-stop for 72 hr. at an output of 250 b.h.p. at 1,500 r.p.m. The fuel consumption averaged 172·9 gr. (0·381 lb.) per b.h.p. hr. and the lubricating oil consumption 4·18 gr. per b.h.p. hr. An average oil temperature of 75° C. was maintained, and the cooling water means were 56½° C. inlet and 65½° C. outlet. The exhaust was practically colourless, and the temperature at the right-hand duct averaged 310° C. and at the left-hand duct 315° C. The scavenging pressure was 371 gr. and the exhaust pressure 100·6 gr.

After the continuous test the engine was run for an hour at 1,500 r.p.m. but producing 275 b.h.p. Under



Cross-section of Winton two-stroke engine producing 75 b.h.p. per 8 in. by 10 in. cylinder at a speed of 750 r.p.m. on a dry weight of 18 to 20 lb. per b.h.p.

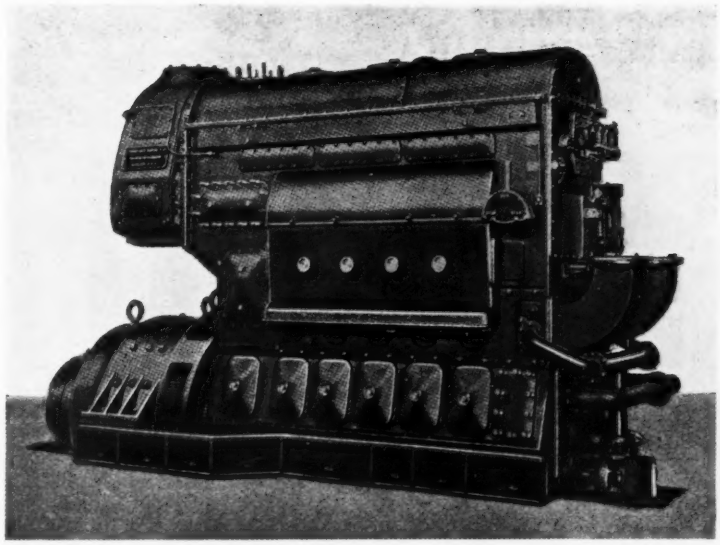
Scavenging air is provided by a single three-lobe helical Roots blower driven at a speed of 1,500 r.p.m. by a chain from the forward end of the crankshaft

these conditions the fuel consumption was 174 gr. (0·384 lb.) per b.h.p. hr., the water temperatures 56° C. and 65° C., the lubricating oil temperature 75° C., and the average exhaust temperature 350-355° C. Subsequently a 15-min. test was given with the engine developing 275 b.h.p. at 1,650 r.p.m. and another during which the engine ran under light load for 30 min. at 600 r.p.m., or 40 per cent. of normal speed. After all of these tests the pistons were only slightly soiled with a soft deposit, which was cleaned off readily by petrol. Under test at 1,100 r.p.m. and developing 210 b.h.p., the specific fuel consumption was only 160 gr. (0·353 lb.) per b.h.p. hr.

The Winton Engine

A study of the Winton engine, which has a standard output of 75 b.h.p. per 8 in. by 10 in. cylinder at 750 r.p.m., shows some interesting and curious results. The low stroke-to-bore ratio and the low piston speed have been noted already; the m.e.p. is high for a two-stroke, *viz.*, 79 lb. per sq. in. The compression ratio is 16 to 1, giving a space of only 0·05 in. clearance between piston and head, the compression pressure is given as approximately 600 lb. per sq. in., and the temperature at full compression, 1,000° to 1,100° F.

Oil cooling of the pistons is favoured, and a sheet-metal baffle is fitted inside the piston to form an oil chamber. A nozzle fastened to the bottom of the cylinder liner directs a pressure stream of oil to this chamber through a passage in one of the gudgeon pin bosses, and drains through a similar passage in the other boss. The amount of oil in circulation rises to as much as 77 gal. a minute, and the make up is almost one gallon per 1,000 h.p. hr. Each

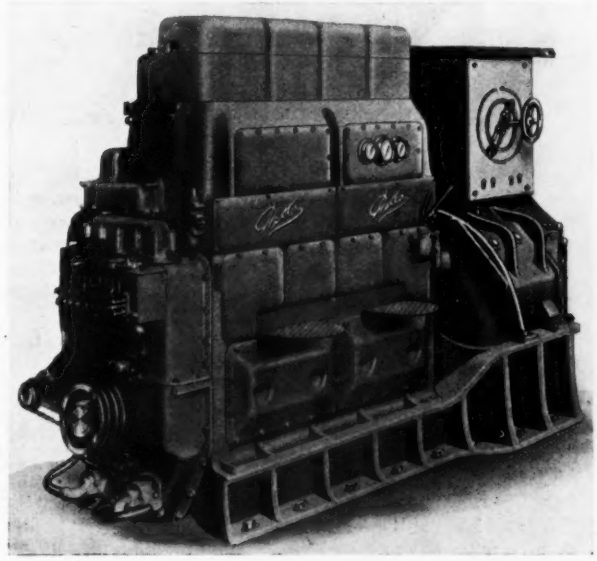


Left: The five-cylinder Fairbanks-Morse opposed piston engine which develops a maximum of 940 b.h.p. at 720 r.p.m. on a weight of about 20 lb. per b.h.p.

piston has four compression rings and two oil-scraper rings, all except one carried above the piston.

The maximum cylinder pressure can be restricted to 850 lb. per sq. in., but in various installations it reaches 1,200 lb. per sq. in. Measured exhaust temperatures at full load have been 450° to 475° F., which is an extremely low value even for a two-stroke, but a more normal figure is 525° to 550° F.; obviously the excess air has been sufficient to mix with the exhaust gases and to have an appreciable cooling effect. The valve event diagram shows that all the Winton railway engines have the unusual feature of closing the four poppet exhaust valves at the same point as the scavenging ports. But the provision of four 2·77 in. silichrome steel exhaust valves with a lift of 0·56 in. in the head seems to have led to reasonable scavenging, judging from the comparatively high m.e.p. with a scavenging pressure of 2¾ to 3 lb. per sq. in and a delivery equal to 1·33 times the cylinder volume assuming 100 per cent. volumetric efficiency of the spiral-lobed Roots blower. The scavenging air is delivered through 24 ports 1·45 in. deep, encircling the cylinder. A full load fuel consumption of 0·37 lb. per b.h.p. hr. with fuel of 18,500 B.T.U.'s calorific value has been obtained on the bench, but the road service consumption using a fuel equivalent to No. 2 boiler oil is about 0·4 per b.h.p. hr. Compared with certain makes of four-stroke engine, the Winton has shown smooth combustion characteristics using a wide variety of fuels, but tests with 83 fuels showed a progressive increase in consumption with decreasing ignition quality from 80 to 20 cetane value, and using fuels below 45-50 cetane brought a definite increase in maintenance work. It is probable

Below: Four-cylinder Petter two-stroke engine with harmonic induction following the Kadenacy patents. The engine is shown coupled to an electric generator, with which it has a common underbed



that the maximum combustion pressures of *circa* 1,200 lb. were obtained with using a fuel of low cetane number.

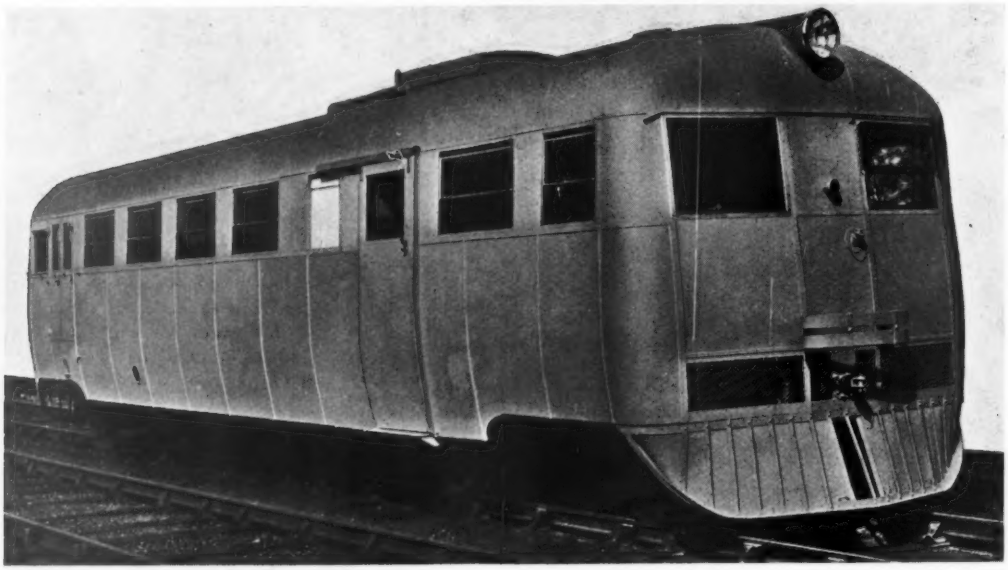
The Petter engine, as proposed for railway transport, is modified from the industrial model and speeded up from 500 to 675 r.p.m. Oil-cooled pistons are used. A description will be found in the issue of this Supplement for September 2, 1938.

CHARACTERISTICS OF RAILWAY TWO-STROKE ENGINES

—	Harlandic		Petter	Winton			C.L.M. Opposed Piston			Fairbanks-Morse Opposed Piston	
Model	—	—	—	12-201A	12-201B	16-201A	6D.V.85	4D.V.120	8D.V.120	—	38D8
No. of cyls.	8	8	6	12	12	16	6	4	8	6	5
B.H.P. (max.)	360	500	525	900	1,000	1,200	165	275	550	300	940
R.P.M.	1,200	800	675	750	750	750	2,100	1,500	1,500	1,200	720
Cyl. bore and stroke, in.	5·3×8·7	7·1×11·8	8·5×13	8×10	8·5×10	8×10	3·35× (4·14×2)	4·73× (5·9×2)	4·73× (5·9×2)	5×(6×2)	8×(10×2)
Piston speed, ft. per min.	1,735	1,575	1,465	1,250	1,250	1,250	1,450	1,485	1,485	1,200	1,200
M.E.P., lb. per sq. in.	70	66	70	79	79	79	99	88	88	70	102
Piston swept volume, litres	25·1	61	73	100	112	133·3	7·16	13·5	27	23·1	83·3
Output per litre, b.h.p.	14·4	8·2	9·2	9·0	9·0	9·0	23·0	18·4	18·4	13·0	11·2
Dry weight, lb. per b.h.p.	15	—	28	18½	18	18½	9	10¾	9½		20½
Compression ratio			15	16	16	16	16	15·9	15·9		
Stroke to bore ratio	1·2	1·66	1·53	1·25	1·18	1·25	1·24	1·25	1·25	1·2	1·25
Piston diameter to length ratio	2·45	2·45	2·0	1·4	1·4	1·4	1·55	1·55	1·55		
Full load fuel cons., gr. per b.h.p. hr.			180	170	170	170	175	175	180		

RAILCARS FOR JAMAICA

Double-bogie design for solo operation of regular and tourist traffic



Double-engined railcar for passenger traffic operation in the West Indies

THE desire to improve the existing passenger services and at the same time to reduce the operating expenses on the Jamaica Government Railway has led to the decision to adopt railcars, and as a preliminary measure three diesel railcars are being put into traffic.

These cars have been built by D. Wickham & Co. Ltd. to the specification and under the supervision of the Crown Agents for the Colonies, and are to operate on the branch lines between Spanish Town and Ewarton and between May Pen and Frankfield, 17¼ and 23 miles respectively, including numerous gradients up to 1 in 33. The cars are also intended to serve the normal heavy tourist traffic between the months of December and March, when steamers are calling at Kingston for a day or two and excursion tours are run from Kingston to Montego Bay. This 112¾-mile line has many gradients, notably between Clarendon Park and Balaclava, where seven consecutive miles of 1 in 33 are encountered. The cars are to make a return trip during daylight.

Mechanical Portion

In order to keep the weight as low as possible, in view of the numerous gradients, the body has been built as an all-welded tubular girder, most of the side pillars as well as floor and roof members being 2⅜-in. square tubes 10 s.w.g. thick. This type of construction is extremely stiff against the bending and torsional stresses encountered, and considerably simplifies construction due to the easier and more dependable welding.

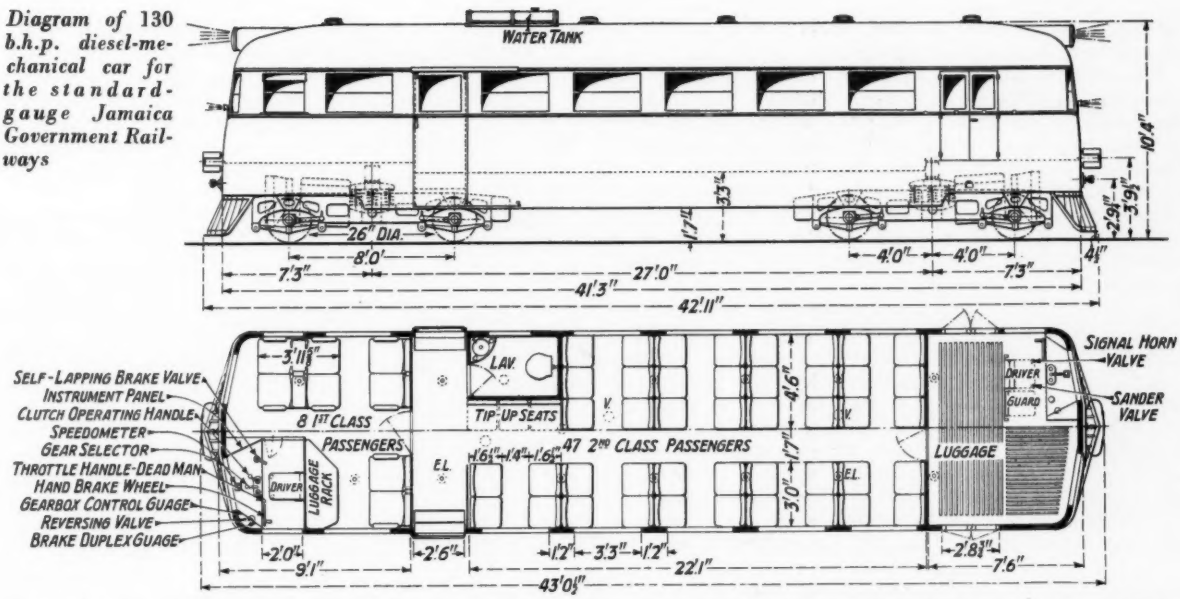
The car body has three main divisions, *viz.* a first class compartment at the front end accommodating eight passengers, a second class compartment accommodating 47 passengers, three of whom are seated on tip-up seats, and a luggage compartment at the rear of the car. The floor height in the second class saloon is 3 ft. 3 in. above rail level, as against 3 ft. 9 in. in the first class and luggage compartments. Entrance is by a 2 ft. 6 in. outside sliding door leading to the vestibule separating the first and second class compartments and providing access to the lavatory; the luggage compartment and the rear driving position, where a guard's seat is also provided, is reached through a 2 ft. 8 in. double folding door. Communication between all compartments is by 1 ft. 7 in. doors.

The interior decoration of the car is light brown with white ceiling throughout, the seats in the first class compartment being upholstered with light blue leather, and those in the second class saloon with green Rexine. For the needs of tourist traffic the second class seats can be replaced by 20 individual armchairs and three tables, a set of which has been supplied with each car. Chromium-plated parcel racks are provided along the walls, and ventilation is by half-drop windows and Monarch ventilators on the roof. Lighting is by 12-volt lamps, three of which are provided in the first, eight in the second class and two in the luggage compartment. Water for the lavatory is supplied from a 30-gal. tank carried on the roof.

Bogie Design

Bogie frames of welded ¼-in. plates with $\frac{5}{16}$-in. braces top and bottom are used. In order to reduce the weight of the bogies, and to improve the riding by reducing hunting, standard hornblocks—which are subject to rapid wear on the dusty sections of the line—have given place to radius bars positively securing the axlebox to the frame *via* Silentbloc joints. The axleboxes carry self-aligning S.K.F. roller bearings, and are provided with underslung semi-elliptic springs with a deflection of 0·96 in. per ton. The springs carry the bogie frame through rubbing pads, the spring ends being guided by 4-in. clips. The bolster is carried on the bogie frame by six helical springs, three on a pedestal inside each bogie side plate. These coils have an individual deflection of 2·02 in. per ton and

Diagram of 130 b.h.p. diesel-mechanical car for the standard-gauge Jamaica Government Railways



ensure adequate springing in the vertical as well as in the horizontal direction when entering sharp, unsuperelevated curves at speed. Houdaille hydraulic shock absorbers are provided across the bolster springs to damp out movement. Both the side support plates on the body, as well as the vertical bolster guide plates are of Mintex-ZSL, the adoption of which eliminates the necessity of lubrication.

Power Equipment

Power is provided by two Perkins P6 six-cylinder engines set to give a maximum of 65 b.h.p. at 1,750 r.p.m. The cylinder bore and stroke are $3\frac{1}{2}$ in. and 5 in. respectively, and the firing order is 1-5-3-6-2-4. The cylinder block and crankcase are cast in one piece of a chromium cast-iron alloy, and the water jackets are carried down the full length of the cylinder bore to ensure maximum cooling for the lubricating oil. Lubrication is ensured by an oil pump driven through spiral gears from the fuel pump driving shaft. Special arrangements are incorporated in the engine whereby filtered air is continuously drawn through the crankcase under all operating conditions, carrying away any blow-by or water

Interior of second class compartment; a handrail for standing passengers is suspended from the roof

vapour, which, if not removed, leads to sludging of the oil and wear of the working parts.

The cylinder head, which incorporates the inlet manifold, is a one-piece chromium-iron casting. The combustion system is on Perkin's Aeroflow air-cell system. By suitably proportioning the air cell, venturi and injection characteristics, smooth combustion with a minimum of ignition delay can be obtained, and the engine can be arranged to run over a wide speed range with a fixed point of commencement of injection. The fuel pump is of C.A.V. manufacture and is fitted with a pneumatic governor.

Transmission

One axle of each bogie is driven *via* a two-plate dry-clutch Mylius preselective air-operated gearbox, cardan shaft, and a reversible axle drive which has a reduction of 3 to 1 and is of Wickham manufacture. Both engine and transmission are mounted on a common subframe, the gearbox being bolted directly to the cast steel rear engine support. The engine subframe is suspended in the bogie through substantial rubber blocks which ensure noise and vibration being kept away from the car body, and on the other hand the provision of a separate engine subframe ensures easy replacement of the power unit over a pit, without the need of lifting the car body. The radiator is carried at the front, inside the bogie frame, and is suspended on rubber pads so that it also can be lowered over a pit without lifting the car body. The radiator header tanks are carried at the front of the car body, thus ensuring ample size and easy filling. A 30-gal. fuel tank is provided at the rear of each bogie.

Westinghouse brakes incorporating emergency features and self-lapping drivers' valves are provided. The clasp rigging is applied by 4-in. light-weight pressed steel brake cylinders, one for each wheel, but the hand brake operates on the driving axles only. Compressed air at a pressure of 80 lb. per sq. in. for the brakes, gear control, reversing and sanding is supplied by two Barr-Hall compressors delivering 9 cu. ft. of air per min. at 975 r.p.m. Deadman features are incorporated in the engine throttle control handle at the driver's left. Should the driver take his hand off this, both engines are stopped immediately, and an emergency brake application is made in two to five seconds by an adjustable time-lag device. The engines are also automatically stopped should the oil pressure drop or the cooling water start to boil.

MORE DIESEL-ELECTRIC TRAINS IN AMERICA

FOR operation on point-to-point services with distances of 88 to 266 miles the Southern Railway of the U.S.A. has introduced six two-car diesel-electric trains, of which the leading vehicle is given over entirely to the power plant, postal compartment, and the baggage compartment. The second vehicle has 32 seats for coloured passengers and 44 seats for white passengers. The trains are single-end drive only, and have an overall length of about 153 ft.

Opposed-Piston Engine

The power car, which is 80 ft. long and has a tare weight of 102 long tons, carries a 940 b.h.p. engine of the two-stroke opposed-piston type made by Fairbanks-Morse. It is the first time this make of engine has been used for regular railway service, but a similar unit ran experimentally a year or two ago. The engine has five 8-in. dia. cylinders and the stroke of each piston is 10 in. The maximum output of 940 b.h.p. is obtained at a speed of 720 r.p.m. In general principle the engine is the same as the celebrated Junkers type, the upper pistons controlling the scavenging air ports and the lower pistons controlling the exhaust ports. The two crankshafts are mechanically connected through rods and bevel gears with flexible couplings inserted in the drive. The engine frame, comprising the cylinder block and crankcases, is of welded steel plate construction, and this structure supports both crankshafts. The upper and lower sumps are of light-weight construction and at the bottom the engine framework, together with the main generator, is mounted on a simple welded steel girder frame. The water-cooled removable exhaust duct forms part of the construction of each cylinder; it is of cast iron and ensures that the hot gases do not come into contact with any of the main frame members.

The cylinder liners are centrifugal iron castings interchangeable throughout, and are easily removable. The pistons are of one-piece cast iron construction, and apparently there is no heat-resisting member on the crowns, such as has been found necessary in other two-stroke opposed-piston engines operating in modern aircraft and railway services. Each main bearing consists of an upper and a lower steel shell lined with centrifugally-cast whitemetal and can be removed without disturbing the crankshafts. Hollow-bored crankshafts are used and are of cast-cored construction; they are made from nickel-chrome-molybdenum alloy steel and have a main bearing diameter equal to the cylinder bore.

The blower for supplying the scavenging air is of a multiple spiral-lobe Roots type, driven from the upper crankshaft by means of helical gears. The relative timing of the impellers is positively maintained by precision gearing. Two gear-type lubricating oil pumps are used; one of them circulates oil from the sump through a duplex oil strainer and oil-cooling radiator back to the sump. The other circulates oil through the piston cooling cavities by means of drilled passages in the main bearings, crankshafts, connecting rods and pistons.

Welded and Riveted Frame

Both cars have a framework made up of Cor-Ten steel assembled by welding as far as the underframe is concerned, but with the body structure riveted. The Carrier air-conditioning system is fitted, and operated in conjunction with the Vapor-Clarkson oil-fired steam-heating system. Under the front end of the power car is a four-wheel carrying truck, but the rear truck is of the six-wheel type and has a Westinghouse electric traction motor on the outer axles. The trucks of both power and passenger cars have Commonwealth cast steel frames on roller bearings. They are air braked by the conventional type of Westinghouse apparatus with blocks operating on the treads of the wheels.

These six trains are to be operated in the Alabama and Tennessee areas and are scheduled to make an aggregate daily mileage of 2,150, equivalent to 358 miles per train per day. On these services the new equipment will replace a total of at least 16 locomotives, six mail and passenger vans, and 10 coaches. The tests made already indicate that sufficient power is available for one to three additional passenger cars to be hauled, as traffic requires. The present schedules do not involve any very high-speed running, the end-to-end speeds not exceeding 45 m.p.h., and some of them being considerably lower.

BOGIE SIDE BEARERS FOR RAILCARS

IN general, the effect of the reduced speeds common on narrow-gauge railways is much more pronounced in regard to the rolling of the superstructure than are the higher speeds found in standard-gauge lines, and care must be exercised in the design of the controlling mechanism to counter any tendency to overturn.

In Fig. 2 is shown a type of bogie side-bearer which is employed on some diesel railcars running over a 2 ft. 6 in. gauge system which abounds in curves of extremely small radii. The ordinary bearer with a clearance of $\frac{1}{16}$ in. to $\frac{1}{8}$ in. would be worse than useless under such conditions, as it permits a definite amount of roll to take place before a stop or retardation of any nature comes into action, and when this does occur the energy already generated may easily be enough to cause derailment. In the design illustrated no movement can take place in either direction except under the control of the bearer, and as this restriction is effected by a light inner spring, a heavy outer spring, and by the cushioning of the imprisoned air in the cylinder, the upper structure cannot develop a roll that is not safe to the vehicle and easy on the track.

Double Spring Control

The unit comprises a combination of two springs within an inner and an outer case, the latter being bolted to the upper framing; the load under normal conditions is sustained by the inner spring. When a rolling action begins, the inner spring on one bearer extends and thus maintains contact between all faces, while the inner and outer springs on the opposite side become still further compressed, and are reinforced to some extent, if the movement is sufficient, by the compression of the contained air.

In Fig. 1 the graphs of loading are shown for the two springs and the slight extra assistance of the air cushion. In the normal working conditions shown by Fig. 2, the inner spring is sustaining a load of 166 lb., and the outer spring 1,060 lb., and these figures rise to 264 lb. and 2,026 lb. respectively when the stop comes into action, plus a further load of approximately 100 lb. due to the air compression in the chamber. When the body rises from the bogie on either side, no change occurs in regard to the outer spring, but the inner spring can extend to a distance of 1·74 in. before the spring is entirely free of load. Taking into account the arm at which the bearers operate, namely, 2 ft. 2 in. from the centre of the vehicle, it has been found in practice that before the inner spring is freed altogether of its load, the increasing forces of the opposite unit are correcting the roll and thus restricting the angular movements to well below 4 deg. on either side of the centre line.

In accordance with modern practice, the working parts are maintained in a good working state by the application of grease lubrication at suitable points, and as the

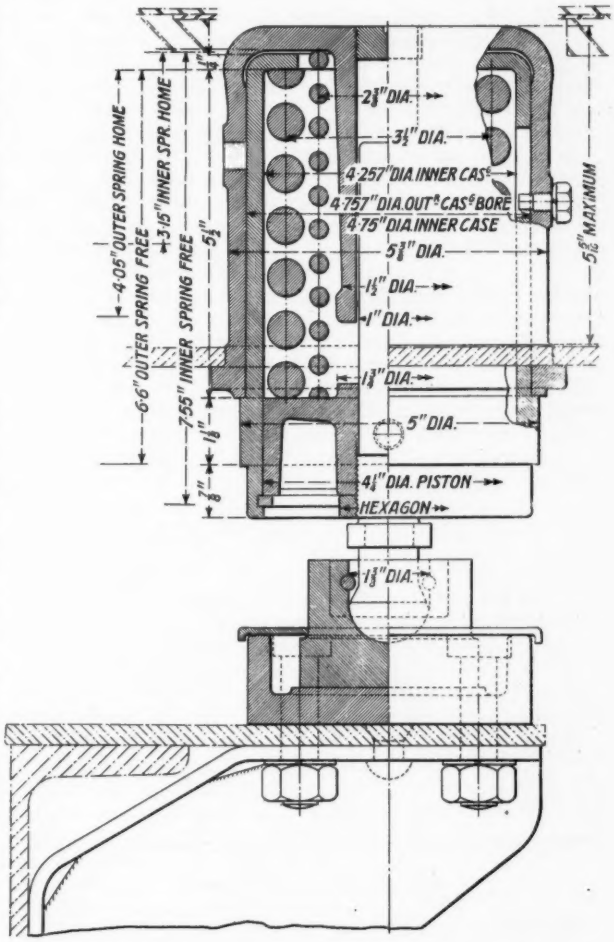


Fig. 2—Arrangement of double helical springs, giving a slight additional air cushioning effect, as fitted to 13-ton railcars on the sharply curved 2 ft. 6 in. gauge Kalka-Simla Railway

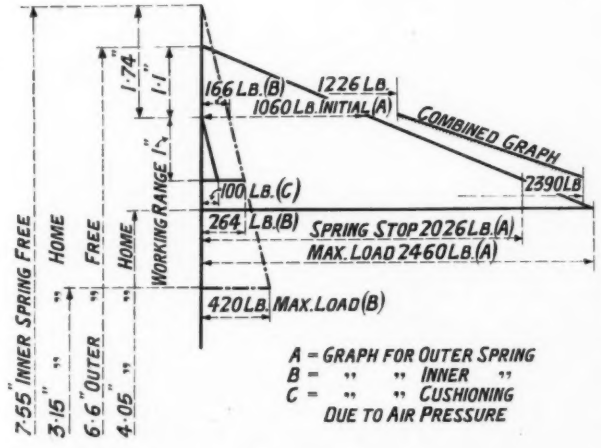


Fig. 1—Loading graph of vertical double helical springs for side control

piston and the cylinder within which it works are ground to fine working tolerances, the working surfaces are at all times kept in a well-greased condition. The pad fitted on the lower end of the bearer centre pin is of steel with its under surface casehardened to a depth of 0·1 in., and the bottom bracket on which this pad slides is made of a special grade of cast iron to resist wear. The cavity in which the pad operates is maintained half-filled with a suitable grade of oil, and the thin sheet-steel cover provided ensures that this lubricant will be kept in a reasonably clean condition, although it is in a position where normally it would pick up a good deal of dust.

A Well-Proportioned Narrow-Gauge Locomotive

FOR surface operation over 2 ft. 6 in. gauge lines at a South African mine, the Hunslet Engine Co. Ltd. has recently built a six-wheel diesel-mechanical locomotive weighing just over 8 tons. The route over which the locomotive works involves a long grade against the load, and it is imperative for efficient working of the traffic that a reasonable speed should be maintained uphill. A very moderate axle load is allowed by the permanent way conditions, but by skilful designing has been kept to a maximum of 2·85 tons within a locomotive weight of 8·1 tons. When operating at full power on the bottom gear step the tractive effort is 4,190 lb. and the factor of adhesion 4·3.

Power is provided by a Gardner 6L2 engine giving 78 b.h.p. at 1,300 r.p.m. in 4¼ in. by 6 in. cylinders, and mounted on the locomotive frame structure. The engine is of standard construction, comprising separate cast-iron crankcase and two cylinder blocks; the cylinder heads are cast separately, in iron. C.A.V. fuel injection equipment is fitted. Great care has been taken to protect all the wearing parts from dust, and adequate filtering of the fuel, lubricating oil and air has been arranged. The air filters have been so located that the driver can clean them and replace them quickly and easily, without taking the side covers from the bonnet. The engine cooling water temperature is controlled by thermostats.

The speeds of 5·9, 11·5 and 18·7 m.p.h. given by the three gear steps of the Hunslet mechanical transmission when the engine is running at top speed, were selected to suit the particular conditions. The friction plate clutch is of large size, is self-cooling, and can stand up to a great deal of slipping while shunting, as well as being able to transmit a 100 per cent. overload. The Hunslet preselective gearbox has always been intended particularly for locomotive applications where rough usage might be expected, and in this installation combines the change-speed box with the reversing gears and final-drive jackshaft. The gearbox is split on the various centre lines so that any shaft may be lifted straight out with minimum disturbance, but when bolted up the whole box can be raised or lowered as a unit. From the jackshaft flycranks the drive is transferred by rods to the 2 ft. wheels, which are spread over a base of 5 ft. 3 in.

American News

Shunting Locomotive Service.—It is claimed that the performance records of 250 Electro-Motive (Winton-engined) diesel-electric shunting locomotives in passenger terminal and yard service on 42 railroads in the U.S.A., show that on a basis of more than 2,000,000 service hours they have been reducing steam locomotive costs by 50 to 75 per cent., and in certain cases they have saved as much as $1,000 a month per locomotive.

Progress Notes.—On September 24 the new nine-car diesel-electric-hauled trains were introduced into the 400 service of the Chicago & North Western Railroad between Chicago and the Twin Cities, replacing the previous steam trains. The locomotive is a double unit, with a 2,000 h.p. power plant in each half. There is a driving cab at each end, so that the locomotive can run round its train and start in the opposite direction with the least delay. The Seaboard Air Line has ordered seven 2,000 b.h.p. diesel-electric passenger locomotives, in addition to the two noted in the issue of this Supplement for September 29. These will help in running the Silver Meteor as a daily service between New York and Florida. The purchase of seven or eight diesel locomotives is being considered by the Erie Railroad, and the Louisville & Nashville has just taken delivery of two heavy diesel shunters. Two Alco diesel shunters have been ordered by the Maine Central, and an Atlas diesel locomotive by the U.S. Navy Department. The Illinois Central is enquiring for 10 diesel-electric switching and freight transfer locomotives for the Chicago area. Two 40-ton four-wheel diesel-mechanical shunting locomotives built by the Plymouth Locomotive Works have been put into yard traffic at Chicago and Sharon. They have a 340 b.h.p. Cooper-Bessemer oil engine running at 900 r.p.m. and an epicyclic gearbox giving four speeds in each direction, and having finger-and-thumb remote control of the gear operations. On the bottom gear step a tractive effort of 27,000 lb. is developed at 3 m.p.h.

American Diesel-Hydraulic Locomotive.—The 63-ton 0-6-0 locomotive, powered by a Hamilton six-cylinder engine giving 400 b.h.p. at 900 r.p.m., which has been built by the Plymouth Locomotive Works, incorporates a hydraulic transmission very much akin to the Voith-Sinclair torque converter. A two-speed gearbox is included to extend the working range of the transmission, and the gear-changing is effected hydraulically.

Publications Received

Engine Bearings.—It is not untrue to say that certain makes of oil engine have given no bearing trouble, but it is just as true that other makes have suffered years on end from low-performance main and big-end bearings. Some time ago a widespread spate of bearing trouble seemed to be saved by the adoption of lead-bronze linings, and this was given so much notice that an opinion was generated among the uninitiated that if it had not liners of this material an engine was scarcely top class. Lead bronze in one or other of its multifarious compositions is still largely used for railway oil engine bearings, as a lining either right round or only for the load-carrying half. A good deal of what is known of such bearings and the alloys is contained in a 46-page book, *Lead-Bronze Bearings*, issued a short time ago by the Copper Development Association, of Thames House, London, S.W.1. Copies can be obtained by making application on firm's headed notepaper.

American Diesels.—It is characteristic of many American technical brochures that they are packed with fulsome phrases rather than facts, but two which have reached us from the General Motors Corporation are happy exceptions. The first, dealing with the Winton series 567 engines, contains an excellent detailed description of the 600-1,200 b.h.p. two-stroke engines of the type which have shared the fame of the Zephyrs, the Cities trains of the U.P.R.R., the Rockets of the C.R.I.P., the Silver Meteor, and other well-known American trains. The second brochure—"The Locomotive of Tomorrow for the Trains of Today"—in six pages gives a wealth of information about the numbers and powers of Winton engines in railway service in Electro-Motive locomotives, together with coloured illustrations of six celebrated diesel trains or locomotives. Winton engines are installed in the locomotives of 49 users in the U.S.A., and aggregate 132,500 b.h.p. in main-line units and 200,000 b.h.p. in shunting locomotives. The main-line locomotives cover over 10,000,000 miles a year, and some of them have run half a million miles before heavy repairs; one of them has run 975,000 miles before general overhaul. Approximately 300 Electro-Motive diesel shunters of 600 to 1,000 b.h.p. are now in service.

Diesel Railway Traction

What Chance for Prosperity?

SAID Colonel W. A. Bristow, Vice-President of the Institute of Fuel, in a recent address: "We shall have to wait for the miracle of returning prosperity to bring our hopes and desires to fruition. And what chance will there be of prosperity unless we plan for it and lay the foundations now? Otherwise there will be immense taxation, colossal fall in national revenue, impoverished foreign markets, a crushing adverse balance of trade, and no spare capital left." A pretty picture, but none the less true. It is time we realised that in a world of abundance all these things are quite unnecessary. While there are goods and services aplenty, there is a shortage of purchasing power to enable them to be bought; so the goods must be exported, and it is the keener and keener fight for ever-dwindling export markets that has led once again to military war. All purchasing power comes out of credit, and the economic life of each individual in the community is directly controlled by its distribution. But as long as we allow the policy and control of public credit to remain, inconsistently with our profession of democracy, outside our democratic constitution, then just so long will we have to endure war, slumps, cut-throat competition, rationalisation, grinding taxation, and the eventual removal of the basis of credit from the bank book entry to the machine gun. As Colonel Bristow put it earlier in his address: "A powerful deterrent to progress is the financial system by which industry is operated."

American Diesel Progress

THE rate of progress maintained in the dieselisation of American railways during the past two years or so shows, if anything, an increase within recent months, as witnessed by the following notes. The Chicago, Burlington & Quincy Railroad is to purchase four 2,000 b.h.p. streamlined stainless steel diesel locomotives. Six of these units will be operated in pairs on the Exposition Flyer and Aristocrat trains, and the seventh will be held as spare for these two trains and for the Denver Zephyr and Twin Zephyr services. The original three-car Zephyr train was recently involved in a collision with a freight locomotive. The Chicago & North Western Railroad has been authorised to purchase two triple-unit 6,000 b.h.p. Electro-Motive diesel locomotives for hauling two 14-car streamlined trains to run between Chicago and California. The Chicago, Rock Island & Pacific Railroad has been authorised to purchase ten 600 b.h.p. diesel-electric switching locomotives at a cost of $625,000 and ten of 300 b.h.p. at a cost of $350,000. The Alabama & Florida Railroad is introducing light railcars on its local services, some of the vehicles being road-railers. Diesel engines of International manufacture are being used. The Illinois Central Railroad has ordered seven 600 b.h.p., one 1,000 b.h.p., and two 2,000 b.h.p. Electro-Motive diesel switching and freight-transfer locomotives, the enquiries for which were noted in our issue of October 27. The Minneapolis, Northfield & Southern Railroad is proposing to purchase three diesel-electric locomotives at a cost of $175,000, and the Ford Motor Company has ordered three 1,000 b.h.p. switching and freight transfer locomotives from the General Electric Company; each is to be powered by two 500 b.h.p. Cooper-Bessemer engines. Together with such recent introductions as the new diesel-hauled 400's on the Chicago & North Western and the Denver Rockets on the C.R.I.P., and trains being built for the Atlantic Coast and Florida East Coast lines, the above orders give a good cross-section of diesel traction activities in the U.S.A. The service given by the express diesel locomotives in the States has been such that Mr. C. T. Ripley, chairman of the Railroad Division of the American Society of Mechanical Engineers, said recently that a radical change in the design of the steam locomotive would be necessary to make it capable of fully competing with the diesel in high-speed service, even when the diesel was working over territory mainly worked by steam locomotives. If a complete division was changed to diesel traction there would be further major savings in the elimination of fuelling and watering facilities, and in intermediate section points.

New Zealand Railcars

THE success of railcar operation in New Zealand was recently favourably commented on by the General Manager of the Government Railways, Mr. G. H. Mackley. In the financial year ended March 31, 1939, the railcar services on the Christchuch—Greymouth—Hokitika and the Wellington—Wairarapa—Palmerston North sections earned £3,476, or £413 in excess of the net earnings for the preceding year. A total of 393,129 miles was run against 362,991 miles during 1937-38, equivalent to an increase of 30,138 miles.

On the Wellington—Wairarapa—Palmerston North route the use of railcars last year effected a direct saving of 31,064 steam train miles to the value of £6,912, which, added to the £3,476 net operating revenue, gave an actual net return from the two services of £10,288. The thrice-weekly railcar service on the Wellington—New Plymouth line instituted in April last, has given complete satisfaction, and the introduction of passenger railcar services on the newly-opened Napier-Wairoa railway on July 1 has already produced most encouraging results. Interest now centres in the ten 275 b.h.p. diesel-electric railcars ordered from England, which are expected shortly. Most of these will probably be used in the South Island, but opportunity is to be taken to compare them in all aspects with the locally-manufactured railcars having English-built motive power, and which have proved so popular with the public. This comparison will be rendered still more interesting because of the different types of transmission utilised, and if one or more cars of each pattern can be run in regular service over the same route valuable data should accrue as to the merits of hydraulic and mechanical transmissions. For approximately equal powers the new cars will have a single oil engine running at about 1,000 r.p.m. against two engines running at 1,900 r.p.m.

XUM

RAILCAR ACCELERATION WITH MECHANICAL TRANSMISSION

An examination of some of the problems involved

By J. L. KOFFMANN

UNTIL a few years ago mechanical transmission was regarded as suitable only for use with engines up to 150 b.h.p.; its present limit is about three times as high, and more care must be devoted to the problem of accelerating high-power cars, with a transmission having only a limited number of gears.

During a start the passengers are affected not by the rate of acceleration dV/dt, but by its first derivative, *i.e.*, by the second derivative of speed, the shock $S = d^2V/dt^2$. During rapid acceleration the accelerating force, together with the force of gravity, forms a resultant applied at a certain angle upon the passengers. A rate of acceleration of 3·3 ft. per sec. per sec. will result in an apparent increase in weight of about one per cent., and the corresponding angle will be about 6 deg., this being the angle which a standing passenger must assume in order to counteract the tendency to fall over. The adjustment to such a position is effected without noticing it as long as the rate of change of acceleration is effected gradually, being troublesome only when this value is high; for example, rates of change of about 1·5 ft. per sec. per sec. are felt as unpleasant. The stress upon passengers due to acceleration is expressed by the equation

$$S_1 = S\left(\frac{d^2V_1}{dt^2} - \frac{d^2V_2}{dt^2}\right)$$

where V_1 and V_2 are the speeds at the beginning and end of a definite interval.

From this it is obvious that the comfort of the passengers can be enhanced by ensuring a gradual alteration in the rate of acceleration, which would require the accelerating force to be increased gradually from zero at the start to a maximum at a point about halfway to the maximum speed, and then by gradually decreasing the rate of change to zero as the speed approaches its maximum. But this is neither possible nor desirable, as to attain a certain speed on these principles the maximum force required must have twice the value of a constant acceleration force, this resulting in a poor utilisation of the power available, and therefore a compromise must be sought.

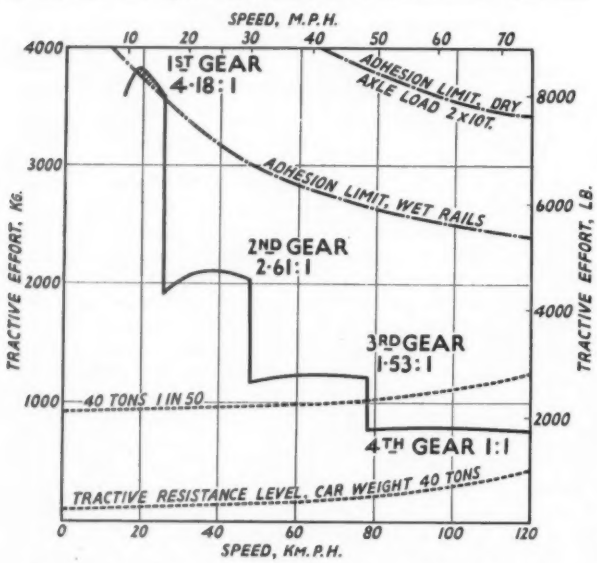


Fig. 1—Speed—tractive effort curves of 440 b.h.p. twin-engined diesel-mechanical railcar with four-speed gearbox and transmission

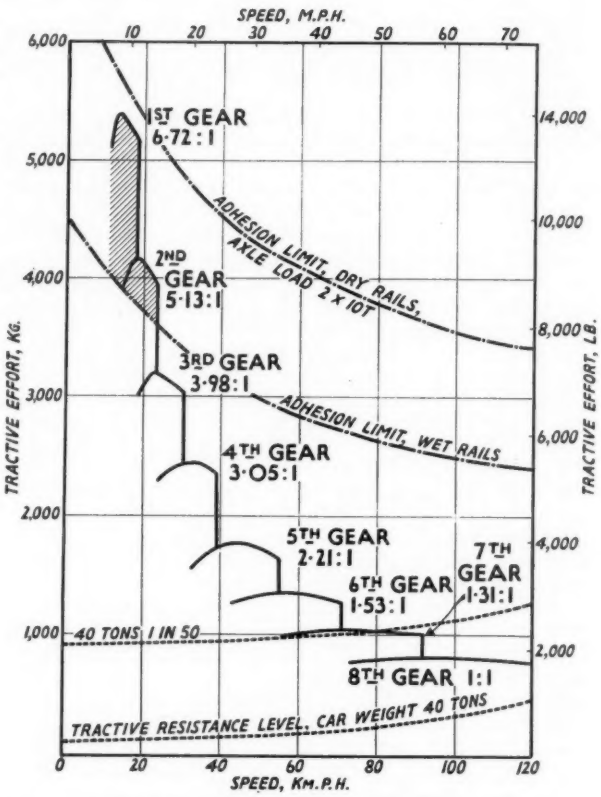


Fig. 2—Speed—tractive effort curves of 440 b.h.p. diesel-mechanical railcar with eight-speed gearbox

Acceleration Progress

At starting the rate of acceleration rises rapidly to its maximum as soon as the clutch is let in. While changing gear, an operation requiring 2 to 3 sec., the tractive effort drops to zero and the speed decreases. As soon as the next gear is engaged and the clutch applied, the car gains speed, the rate of acceleration decreasing as the speed increases. This interruption of the tractive effort and the consequent jerks and loss of time due to gear-changing are at present one of the main disadvantages of mechanical transmission. Four- and five-speed transmissions are widely adopted even for moderate top speeds, but some operators advocate up to eight speeds in order to obtain more even, yet rapid, acceleration. But it seems natural that the ultimate development should tend towards a sustained drive, such as given by the Freeborn box, and from there to an infinitely-variable mechanical drive. Another transmission for which sustained drive is claimed

is that just developed by Ansaldo, in Italy. This gear is of an epicyclic type, and is engaged through the medium of mercury-filled rotary cylinders coupled to the planet wheel sets.

As an example of the conditions encountered, consider a twin-engine bogie railcar with rounded front, weighing 40 tons when fully laden, and with power furnished by two Saurer BXD engines fitted with Büchi pressure-chargers to give a maximum individual output of 220 b.h.p. at 1,500 r.p.m. The tractive effort curves are plotted on the assumption that the overall efficiency of the power plant is 85 per cent., and the train resistance curves are calculated to the formula of the German State Railway for a standard-gauge bogie car with curved front,*

$$R = 5{\cdot}5W + 0{\cdot}054A\ (0{\cdot}16V)^2$$

where R is the total resistance in lb., W the car weight in tons, V the speed in m.p.h., and A the frontal area in sq. ft.

Tractive effort curves for both four- and eight-speed transmissions are shown in Figs. 1 and 2. The coefficient of friction between wheels and dry rails may be taken as $f = \frac{565}{26 + V} + 11{\cdot}6$,† this value being reduced by about 30 per cent. with wet rails. The wheels may spin in first and second gear with the multi-speed transmission, and there is also a possibility of spinning on wet rails in the first gear of the four-speed unit. A higher tractive effort is ensured at starting with the eight-speed gear, but although on a grade of 1 in 50 a speed of 49 m.p.h. can be maintained with the four-speed gear, only about 44 m.p.h. can be attained with the eight-speed transmission.

Notwithstanding the fact that higher rates of acceleration are ensured in the top gear-steps with the multi-speed transmission, the advantages gained are more than offset by loss of time required for gear-changing. The loss in speed as well as the distance covered while gear-changing can be derived from the equation of a movement against a resistance increasing with the square of the speed, the simplified resultant formulæ* for the car concerned being :—

$$V_1 = \frac{1610WV - 35{\cdot}32\,(2{\cdot}5 + g) \times W \times t}{1610W + 0{\cdot}0132A \times V \times t}\ \text{m.p.h.}$$

$$l = \frac{1610WV - 17{\cdot}66\,(2{\cdot}5 + g) \times W \times t}{1610\text{W} + 0{\cdot}0066A \times V \times t} \times \frac{t}{11{\cdot}8}\ \text{ft.}$$

where V is the speed in m.p.h. at the beginning and V_1 the speed at the end of each gear-change period, t the time required for gear-changing in sec., g the gradient in per cent., and l the distance covered during gear-change, in ft.

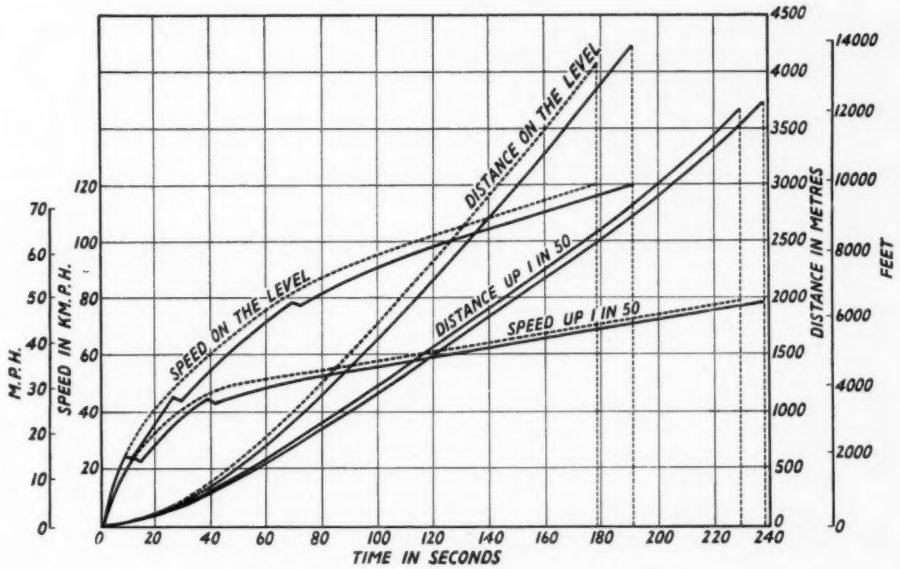


Fig. 3—Performance of 440 b.h.p. twin-engine diesel-mechanical railcar on the level and up a grade of 1 in 50 ; four-speed gearbox

The performance of the 440 b.h.p. car with a four-speed gearbox along the level and up a gradient of 1 in 50 is shown in Fig. 3. The dotted lines represent the results obtained when using a sustained-drive transmission with the same gear ratios. The performance with an eight-speed gearbox is shown in Fig. 4.

Comparison of Performance

With a normal transmission the advantages obtained in using a sustained-drive arrangement are not great so far as gains in time and distance are concerned, but acceleration is achieved more smoothly, notably when changing from first to second gear. The eight-speed gear, however, in normal circumstances and with the ratios chosen, seems as if it would be of advantage only when arranged as a sustained drive ; otherwise the time required for changing through the increased number of gears would result in a marked handicap against rapid acceleration. Some advantage would be gained when starting on gradients, as here the increased number of gears would ensure a better distribution of tractive effort between the fourth and seventh gears, a feature which can be of importance when considering that a slight change of slope of the speed-time curve results in a considerable alteration in the time required for acceleration.

From the considerations noted above, it would appear that with medium and high power railcars and multiple-

* Judtmann : " Motorzugförderung auf Schienen " : Vienna. 1938, p. 18.

† Kother : " Fahrzeitermittlung und Bestimmung der Beanspruchung der Fahrmotoren elektrischer Triebfahrzeuge." *Elektrische Bahnen*, Dec. 1937, p. 297.

* Opatowski : " La Perte de Vitesse des Automotrices à Transmission Mécanique au cours du Changement de Rapport de Transmission " (*Chemins de Fer et les Tramways*, August/September, 1936)

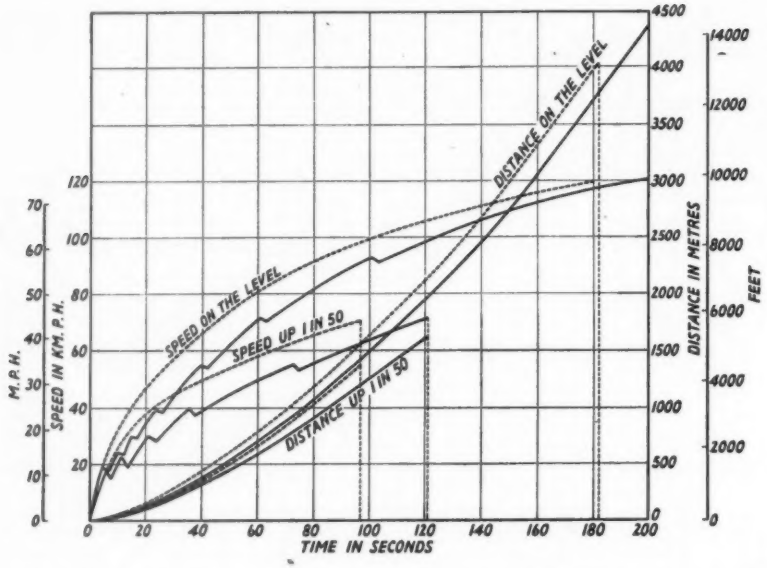


Fig. 4—Performance of 440 b.h.p. twin-engine diesel-mechanical railcar on the level and up a grade of 1 in 50; eight-speed gearbox. Compare with Fig. 3 and note how acceleration up 1 in 50 grade is better than with a four-speed box, although the fewer-speed box gives rather better results along the level

unit trains the present standard types of four- and five-speed transmissions with interrupted drive can meet the operating requirements. The sustained drive would be of some advantage so far as passenger comfort is concerned and also in permitting a simple fully-automatic control, thus ensuring to mechanical transmission one of the advantages claimed for electric and hydraulic systems. The gains in reducing the time required for acceleration by the use of an eight-speed box are negligible, yet the bulk, weight and both first costs and maintenance expenses might be higher. Should eight or more speeds become desirable for operation over hilly country, the loss of time and speed due to gear-changing would probably justify the adoption of a sustained-drive transmission, provided that a unit suitable for railway requirements could be obtained.

Diesel and Steam Traction on Danish State Railways

FROM the Danish State Railways' report for the year ending March 31, 1939, it appears that the eight Lyntog sets accounted for about 1·7 per cent. of the total number of passengers but for about 15 per cent. of the passenger-miles. The electrified suburban trains in Copenhagen took 46 per cent. of the passengers, but only 13 per cent. of the passenger-miles. Of a total of 30,100,000 train-km., 59·3 per cent. were made by steam locomotives; 6·3 per cent. by the Lyntogs; 7·4 per cent. by electric trains; and 27 per cent. by petrol and diesel railcars. Of the passenger trains, 52·9 per cent. were hauled by steam and 47·1 per cent. by electric, petrol or diesel power. The average occupation of the seats in all trains was 30 per cent., but the percentage for the Lyntogs varied from 49 to 72 for the different trains, with 62 per cent. as an average. The Lyntog *Englaenderen* (Copenhagen—Esbjerg) had in July and August, 1938, an average occupation of 89 per cent.

The steam locomotives in use and under repair ran an average of 58,060 km. (36,060 miles) each; the electric motor-coaches in the Copenhagen suburban services 82,392 km. (51,180 miles) each; and the diesel-electric railcars 114,790 km. (71,250 miles). Nevertheless, most of the railcars are used on local trains stopping at nearly all stations, and some of them are even used on suburban service. The Lyntog average mileage was 236,813 km. (147,000 miles) per set. The diesel-electric railcars showed averages of 1·02 litres of fuel per km. and 0·0302 kg. of lubricating oil per km., and together these two items cost 9·48 øre per km. For the Lyntogs the figures were 1·22 litres of fuel oil per train-km. and 0·0182 kg. of lubricating oil per train-km.; the expenses were 10·36 øre per train-km. Compared with these, the steam locomotive coal consumption averaged 12·7 kg. per km., and the expenses for coal and lubricating oil were 40·5 øre per km.

Maintenance Costs

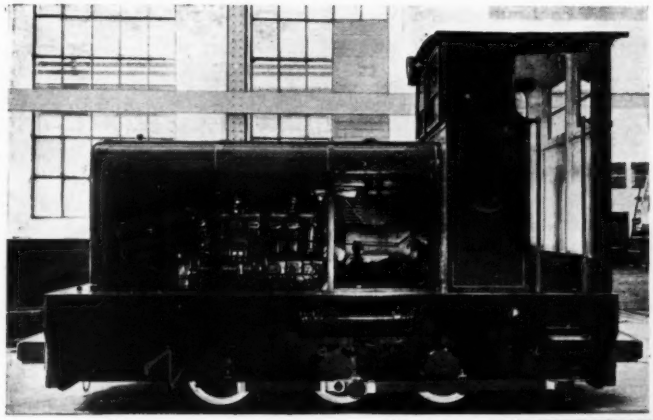
Mr. Schilder, mechanical engineer in charge of the railcar depot at Copenhagen, recently stated that the maintenance expenses for a four-car Lyntog amounted in all to about 37 øre per train-km., but it was impossible to say how much of this was for maintenance of the power plants and how much for the mechanical portions. However, a four-car Lyntog may be said to correspond to an engine and four bogie carriages. As the average maintenance expense for a bogie carriage was 1·3 øre per km., the cost for four cars would be 20·8 øre per train-km. It was true that the Lyntog sets had only six bogies instead of eight, but on the other hand the cleaning of the Lyntogs was more thorough and frequent than for ordinary stock and was carried out at night. The difference between 37 øre and 20·8 øre—16·2 øre per train-km.—would correspond to the maintenance cost of the 1,100 b.h.p. diesel-electric power equipments. For a diesel-electric railcar the maintenance cost amounted to 13·4 øre less 5·2 øre for the maintenance of the mechanical portion, so that the maintenance cost of the power plant and transmission was 8·2 øre per km. for a 550 b.h.p. car. Against these figures, the average maintenance cost for a steam locomotive was 14·0 øre per km., so that the maintenance cost of a diesel railcar was considerably below that of a steam engine in spite of the railcar's double set of machinery. Even a Lyntog, with its four engines and generators, compared favourably with the average steam locomotive.

Recent Small Diesel Locomotives

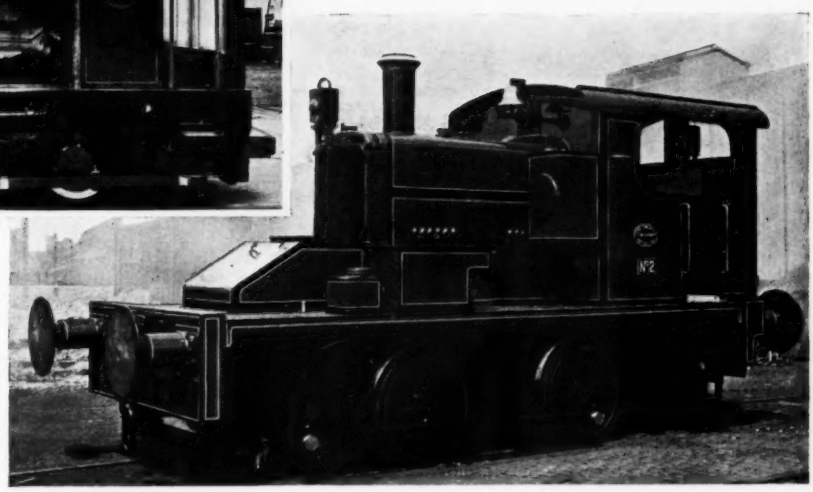
Standard productions of English builders for home service and for export

AT a time when large orders are few, the smaller locomotive or railcar, built very often in ones and twos, gains a little more limelight, and it becomes clear that technical excellence of design and construction is not confined to units which come under the eye of the publicist. Despite the glamour surrounding express steam locomotives, and the attention paid to them, they form but a fraction of a large railway's stock, and most of the money is earned by less pretentious locomotives. And so it is in the diesel world—on large and small railways, industrial plants, docks, and harbours.

The true flame-proof locomotive is confined in its service almost entirely to underground haulage in gassy mines and to a lesser extent to high-explosive factories. A far larger number of diesel locomotives is operating with equipment which is not flame-proof in the complete sense, but which is certainly spark proof, and is flame-proof under more normal working conditions.



Left: Gardner-engined locomotive built by the Drewry Car Co. Ltd., for service in South Africa at an altitude of about 5,000 ft. above sea level



Right: 85 b.h.p. Fowler diesel-mechanical locomotive for operation in the yard of an alkali company where dangerous conditions are found

An example of this type of construction is an 85 b.h.p. Fowler locomotive built for the standard-gauge yard system of the Castner-Kellner division of Imperial Chemical Industries. With 36-in. wheels spread over a base of 5 ft. 6 in., it can negotiate curves of 80-ft. radius; it is 22 ft. long over buffers, and the basic design can be built with an overall width as low as 7 ft. 9 in. The weight is 20 tons, and the maximum tractive effort 8,500 lb., giving a factor of adhesion of 5·3. A hand screw brake is fitted to all wheels, and the construction of the mechanical portion is along normal lines. Power is provided by a Fowler-Sanders oil engine giving 85 b.h.p. at 1,100 r.p.m., and drives a Fowler mechanical four-speed transmission giving track speeds of 3, 5, 8, and 12 m.p.h., with corresponding tractive efforts of 8,500, 5,100, 3,187, and 2,125 lb. Similar Fowler locomotives for operation in dangerous areas, but with 150 b.h.p. Fowler-Sanders engines and with working order weights of 30-31 tons, have been supplied recently to the Anglo-American Oil Co. Ltd., and other firms.

Several Drewry standard four-wheel and six-wheel diesel shunting locomotives for narrow, standard and broad-gauge systems are included in this year's exports. A six-wheel model for service on 2-ft. gauge lines in South Africa is illustrated on this page. Power is furnished by a Gardner 6LW engine normally giving 102 b.h.p. at 1,700 r.p.m., but set to give 83 b.h.p. at the same speed under site conditions, the line being located high above sea level. The engine drives the wheels through a Vulcan-Sinclair fluid coupling, a Wilson-Drewry preselective epicyclic gearbox, cardan shaft, and reversing gear with worm reduction. With the engine running at top revs, the track speeds are 2·9, 5·25, 8·5, and 14 m.p.h. Straight air and hand screw brakes actuate blocks on all six 24-in. wheels, and pneumatic sanding is fitted. The weight in working order is 12¾ tons.

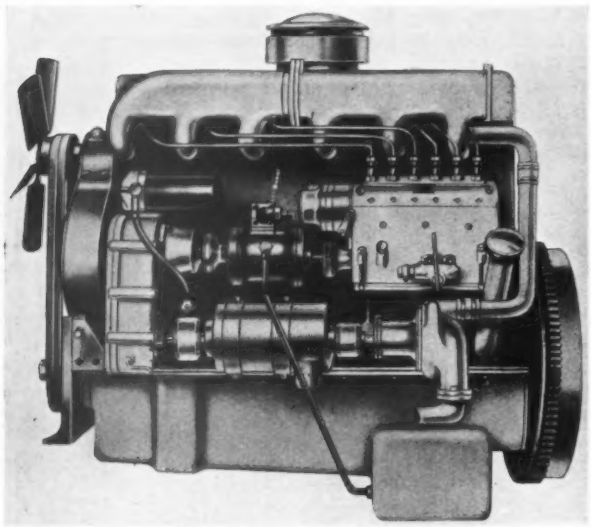
A four-wheel model, powered by the same engine and derated to about the same power to suit altitude conditions, has been supplied by Drewry to the Calcutta Electric Supply Co. Ltd. In this example the speeds given by the Wilson-Drewry gearbox are 3·9, 6·8, 10·3, and 16·2 m.p.h., the wheels are 33-in. in diameter, and spiral bevel reverse is used. Hand screw and Westinghouse air brakes are fitted. As in the South African locomotive, the radiators are of the Spiral Tube type and C.A.V. auxiliary electrical equipment is embodied.

NEW TYPES OF OIL ENGINES

Some recently-introduced makes which have possibilities for railcar and locomotive applications

THE range of high-speed diesel engines made by F. Perkins Limited, of Peterborough, has just been increased by a six-cylinder engine set to give a maximum of 115 b.h.p. at 2,000 r.p.m., that is, an increase of about 50 per cent. over the P6 engine, hitherto the largest of the Perkins type. This output is developed in cylinders with a bore of 4⅜ in. and a stroke of 5 in., giving a piston-swept volume of 7·3 litres. The dry weight, including accessories, is 930 lb., equivalent to a little over 8 lb. per b.h.p. It is probable that for railway work the speed will be limited to 1,500 or 1,750 r.p.m. and the output to 90-100 b.h.p., although under certain conditions a two-hour output of 110 b.h.p. at 2,000 r.p.m. will be permitted. A maximum torque of 307 lb.-ft. is attained at a speed of 1,200 r.p.m.

The cylinder block and crankcase are cast in one piece in chromium cast iron. The water jackets are carried the full length of the cylinder block and encircle the main



New Perkins engine giving a maximum output of 115 b.h.p. at 2,000 r.p.m.

bearing seatings in order to ensure the maximum cooling of the lubricating oil. No liners are used, but there is ample metal in the cylinder walls to allow of reboring after the maximum permissible wear has taken place. The cylinder heads are cast in two blocks of three and chromium iron is the material used. The camshaft is carried in a trough high up on the offside of the cylinder block and the motion of the cams is transmitted to the rocker arm through long tappets; no push rods are used. Both main and big-end bearings have steel shells with a lining of lead bronze. The pistons are of aluminium alloy and carry three pressure and two scraper rings, all located above the gudgeon pin.

The combustion system used is the Perkins Aeroflow, which incorporates a spherical air cell in the cylinder head. This air cell is connected to the cylinder by a cylindrical throat and the injector has two nozzles, one delivering fuel to the air cell itself and the other nozzle delivering into the venturi. It is claimed that by a suitable proportion of the air cell, venturi and injection characteristics, smooth combustion can be obtained and the engine arranged to run economically over a wide range of speed and load with a fixed point for the beginning of injection. Both fuel pump and atomisers are of C.A.V. manufacture.

Heavy Vertical Type

The second of the two new English railway oil engines is suitable more for locomotive applications and not for railcars. It is made by Ruston & Hornsby Limited, of Lincoln, and is intended to replace the larger sizes of the existing VR series. The smaller engines of the VR type, such as the 48 b.h.p. model illustrated and described in the issue of this Supplement for September 3, 1937, will continue to be used for small locomotives and loco-tractors.

These new engines are of a fairly heavy type, and their application by reason of weight and space is limited so far as locomotive work is concerned, mainly to the 4-, 5-, and 6-cylinder VAB models, giving 90, 112, and 135 b.h.p. respectively at 750 r.p.m. Compared with the type it replaces, the principal difference is the provision of an open type combustion chamber with overhead valves, and a new fuel injection equipment incorporating separate Ruston fuel pumps for each cylinder mounted alongside the cylinder block. The fuel is injected into the combustion chamber through Ruston's Mark 37 atomiser. The crankcase is carried well down below the centre line of the engine and to it is bolted a substantial cast-iron sump through which the load and weight of the engine are transmitted to the mounting frame. The crankcase and cylinder block are cast integrally of iron, and wet-type liners are inserted from the top. The crankshaft is a single-piece forging and is carried on bearings composed of steel shells lined with anti-friction metal. The big-end bearings are of a similar type but the small end, which carries a fully-floating gudgeon pin, is fitted with a plain bronze bush.

Supercharged Models

A range of pressure-charged engines has just been introduced by Ruston, covering ten models varying from 415 to 1,560 b.h.p. at speeds varying from 600 to 375 r.p.m. Of these, only four are suitable for locomotive application, the size and weight preventing the other engines from being installed within the English loading gauge. The engines themselves are of similar design to the new VB engines, but have the advantage of a Büchi exhaust-gas pressure-charger which increases the output by 30 to 50 per cent. at the same rotational speed at full load. The dry weight varies from 48 to 52 lb. per b.h.p. and the engines thus are suitable mainly for large shunting locomotives. In the standard engines the pressure-charger is mounted on the front end of the engine.

A New Horizontal Model

An engine recently brought out in this country which has some claims to be considered for rail traction is the Blackstone-Brush horizontal type, which is made in even numbers of cylinders from four to 12. The maximum output is 28 b.h.p. per cylinder at 900 r.p.m., corresponding to a piston speed of 1,500 ft. per min. and a m.e.p. of 87 lb. per sq in. The 6¼ in. by 10 in. cylinders are equipped with Loded-iron liners, and each cylinder bank has a chain-driven camshaft of its own; the exhaust

valves are above and the inlet valves below, and both are arranged in cages. A C.A.V. fuel injection pump on each cylinder block is driven from the corresponding camshaft. The connecting rods of opposing cylinders are arranged so that one big end forks overs the other. Balance weights are fitted to prolongations of the crank webs. A dry-sump pressure lubrication system is used and incorporates an oil cooler below the sump at one end of the engine. Burgess silencers are fitted as normal equipment on the air intakes. The weight and bulk of this new Blackstone-Brush engine prevent installations below the floor of a railcar, which is the principal advantage of the horizontal engine as far as rail traction purposes are concerned, but there are no such reasons preventing its adoption for shunting locomotives, and the engine characteristics for such a service do not seem too high.

A REBUILT DIESEL RAILCAR

Interesting electric transmission equipment installed in narrow-gauge vehicle

LOCAL trains on the Diekirch—Vianden metre-gauge railway in Luxembourg are operated by two double-bogie diesel-electric railcars which are rebuilds of two petrol cars first introduced about 25 years ago. In rebuilding, the owning company desired that certain items of auxiliary apparatus and other details should be used, as well as most of the mechanical portion, and this led to the adoption of unusual methods in making the equipment as a whole quite up to date.

As now running, each car tares 28 tons, carries 32 seated and 20 standing passengers, has 28 sq. ft. of luggage space, and has a nominal top speed of 60 km.p.h. (37 m.p.h.); the overall length is 13·35 m. (44 ft.). The main alterations to the mechanical portion were the strengthening of the bogie springs and an increase in the power of the Westinghouse air brake. The engine now used gives a nominal maximum output of 180 b.h.p. at 1,180 r.p.m., but under certain conditions is allowed a top capacity of 200 b.h.p. at the same speed. It idles at 600 r.p.m. and has load speeds of 630, 850, 1,100, and 1,180 r.p.m.

Engine and Auxiliary Equipment

The location of the new engine-generator set presented certain difficulties, as it had to be lodged transversely in an engine room of limited dimensions. The combination is mounted on a heavy bedplate bolted to the frame of the car, and the whole assembly can be taken out through the side of the car. The existing water cooler on the roof had to be used, but additional gilled tubes were necessary to suit the increased output of the diesel engine.

In the original petrol car the motor-compressor set for the braking air (6·5 h.p. 600 volts) and the heating plant (3 kW at 550 volts) were connected to the generator, and a small belt-driven dynamo was used to charge the 12-volt lighting battery. The railway company desired that the compressor and heating plants should be used again, but the lighting plant had to be renewed and the tension raised to 24 volts. The voltage ratios of the main and auxiliary circuits were thus determined in advance. As the length—across the coach—was very short, an overhung auxiliary generator was not possible, and placing the auxiliary generator above the main machine and driving it by a belt was not considered a satisfactory solution, as poor results had been obtained with earlier plants having this arrangement.

The simplest and most practical solution was considered to be a voltage converting set, converting the variable voltage of the main generator to a constant voltage of 24. The two traction motors are permanently connected in parallel to the main generator, and the compressor set, heating circuit of the car and the trailer, and the voltage converter are also connected permanently to the main machine. The converter supplies the separate excitation of the main generator, the battery (which now caters for both starting and lighting), and the control and lighting circuits. This arrangement was evolved by Brown Boveri, which firm designed and supplied the complete electrical equipment for the rebuilt car.

Transmission Constituents

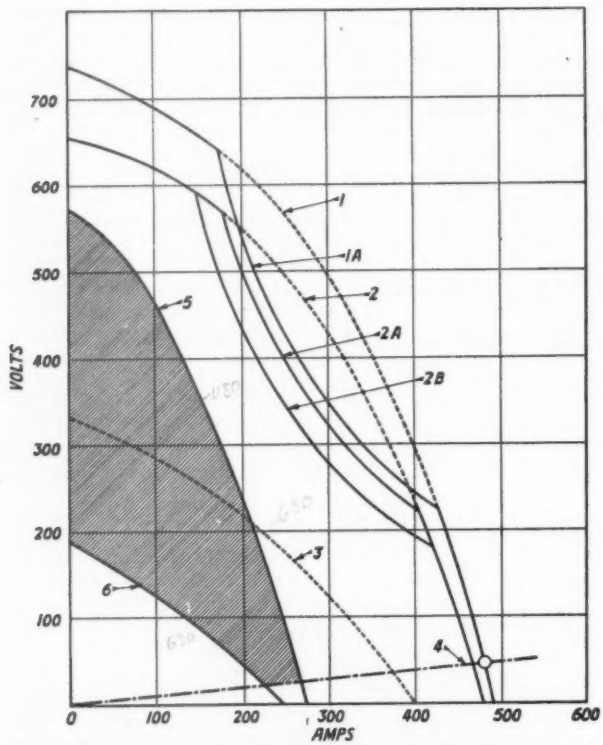
Comprising a d.c. compound motor built into a common housing with a d.c. shunt generator, the converting set is located in the engine room. The motor is connected straight to the terminals of the main generator and is supplied with current at a voltage varying from 220 to 630. The generator of the set delivers current at a tension of 26-30 volts to charge the battery and to supply the control and lighting circuits. A quick-acting voltage regulator is used to regulate the generator voltage by influencing the field of the latter. The Tudor lead-acid battery is composed of four crates of six cells of 320 amp. hr. at the 5-hr. rate of discharge. The rated discharge voltage is 22 at 64 amp.

The self-ventilated main generator has only one flange bearing, of the roller type, which is located at the commutator end. The geared rim with which mesh the pinions of the two electric starting motors for the diesel engine is secured to the main generator fan-wheel. The generator is of the six-pole type with a one-hour rating of

ENGINE OUTPUTS ALLOWED BY BROWN BOVERI SERVO FIELD REGULATOR CONTROL

Running step	Diesel engine output			
	Speed, r.p.m.	Torque, per cent.	Output, b.h.p.	Output, per cent.
1	630	85	82	45
2	850	85	110	61
3	850	100	130	72
4	1,100	85	143	79
5	1,100	100	168	93
6	1,180	100	180	100
7	1,180	111	200	111

112 kW (402 volts 278 amp.) and a continuous rating of 116 kW (546 volts 212 amp.), both at 1,180 r.p.m.; it has self excitation as well as separate excitation, and a counter-compound winding to limit the current at starting. There are no over-current relays in the traction motor circuit. The four-pole nose-suspended traction motors have roller bearings for the armature shaft and bush bearings with pad lubrication for the axles. The one-hour rating of each motor is 72 h.p. (402 volts 133 amp.) at 922 r.p.m., corresponding to a track speed of 24·5 km.p.h. (15·2 m.p.h.) with wheels having a worn tyre diameter of 760 mm. (30 in.) and a gear ratio of 1 : 5·78. Allowing an average constant output of 15 h.p. for



1, 2, 3.—Voltage in function of current strength at the constant engine load speeds of 1,180, 1,100 and 630 r.p.m., and maximum separate excitation at 25 volts.
1*a*, 2*a*, 2*b*.—Generator voltage regulated by the servo field regulator as function of current strength at 1,180 r.p.m. and 100 per cent. torque; 1,100 r.p.m. and 100 per cent. torque; 1,100 r.p.m. and 85 per cent. torque.
4.—Resistance line of the load-current circuit.
5, 6.—Voltage as function of current strength with weakened separate excitation (excitation branch of servo field regulation cut out) at constant speeds of 1,180 and 630 r.p.m.—with only one traction motor working.

Generator characteristics and regulation curves given by Brown Boveri servo field regulator

auxiliary services, the tractive efforts attained at the wheel rims are 2,800 kg. (6,180 lb.) from zero up to 9·5 km.p.h. (5·9 m.p.h.); 1,380 kg. (3,050 lb.) at the one-hour rating speed, and 860 kg. (1,900 lb.) at the continuous rating at a speed of 40 km.p.h. (24·8 m.p.h.).

Electric Control

Brown Boveri servo field regulator control is embodied in the rebuilt coach, and in order to attain seven regulating steps with four fixed load speeds of the oil engine the torque is stepped at constant rotational speed by electromagnets built on to the servo field regulator. The output adjustment for the different control steps is as given in the attached table, and the illustration shows the characteristics of the main generator and the regulating curves of the servo field regulator at three of the four fixed service speeds, viz., 1,180, 1,100 and 630 r.p.m. With a separate excitation current at 25 volts there is a maximum starting current of 475 amp.—at the point of intersection of curve 1 with the resistance line 4. The separate excitation circuit of the main generator consists of two parallel branches, one of which supplies the constant basic excitation, and the other is regulated by the servo field regulator. If a defect develops in one of the traction motors, the regulated excitation and the servo field regulator are cut out along with the defective motor. The control system then operates as characteristic control and permits the service to be maintained. The conditions are so chosen that under standard separate excitation voltage the traction motor which remains at work can be loaded only within the shaded area bounded by lines 5 and 6 in the accompanying illustration; the allowable starting current cannot be exceeded, even under maximum separate excitation voltage.

Tractive effort and speed are adjusted while the car is running from a controller in each driving cab. This controller has a main (running) drum with a locking position, a dead position, and four service positions; and a secondary drum with a dead position and four service positions. The speed and output of the oil engine are adjusted by the main drum, and the direction of rotation of the traction motors is determined by the secondary drum, which to that end is equipped with heavy-current contacts. The secondary drum also serves for changing-over operations on auxiliary services when the coach is travelling, or stopped with the engine running. An electro-pneumatic speed adjuster is used to alter the tension of the centrifugal governor spring when the speed of the engine is being set. It has five compressed-air pistons for six adjustable steps including a dead position, and these pistons are controlled by electro-magnet valves lodged in the housing of the speed adjusting apparatus. The pistons adjust the governor spring through a rod, and steps 1 to 4 can be adjusted as desired. The engine is stopped by cutting off the current from all the electro-magnets, and this causes the governor spring to be slackened sufficiently to reduce the fuel charge to such a degree that the engine stops.

Trade Publications

Gas Producer.—The Koela gas producer, recently taken over by the Brush Electrical Engineering Co. Ltd., and now known as the Brush-Koela, is described in a folder just issued by the maker.

Air Filters.—An efficient type of oil-bath filter suitable for application to oil-engine air intakes is described in bulletin AMA sent by Air-Maze (Great Britain) Limited, of Bush House, London, W.C.2, and the same company's filter panels, such as might be used in the intake to the engine room of a diesel locomotive, are dealt with in bulletin AMB.

Timken Times.—Mr. E. H. Doughty's exposition of the tapered roller bearing, which was a prominent feature of the first number of *Timken Times*, has been supplemented in the second issue by concise notes on bearing mounting practice. Interesting, and to us hitherto unrealised, applications of Timken bearings to road transport and to a variety of mobile and fixed plants, are also illustrated and described.

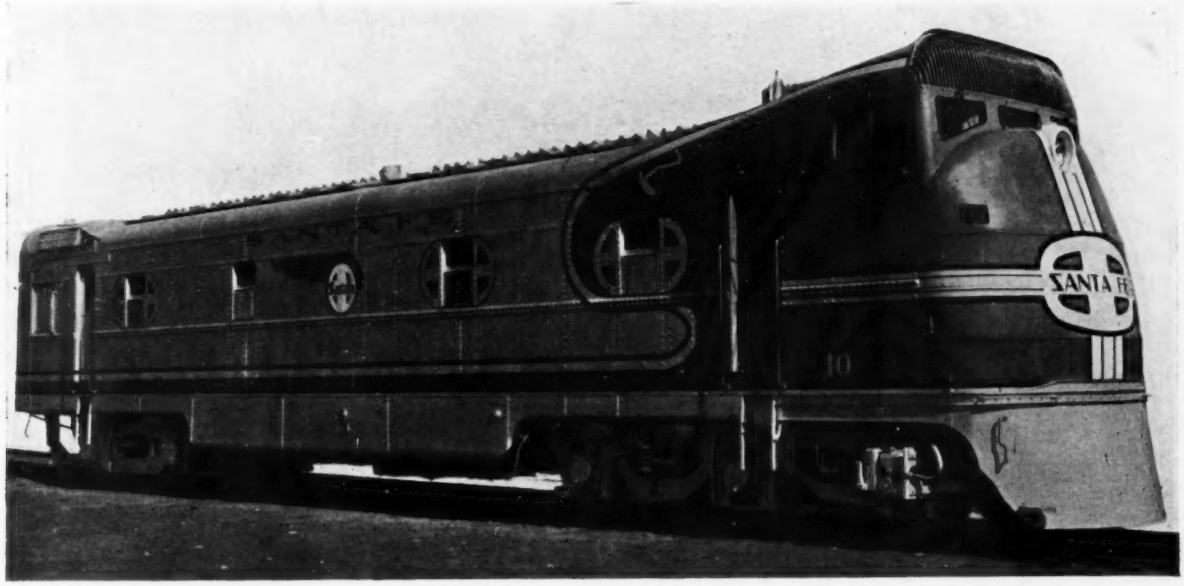
Oil Strainers.—The principle of forcing the oil through a tightly-packed roll of straining material impregnated with a chemical compound is used in the Simmonds Fram oil cleaner, the various models of which are described in a brochure and installation sheets issued by Simmonds Aerocessories Limited, Great West Road, Brentford, Middlesex. This firm also makes an ingenious form of oil-condition gauge which is incorporated with the dip stick.

Ruston Engines.—The range of Ruston vertical engines has been extended by the VB type covering outputs of 22½ b.h.p. at 750 r.p.m. to 130 b.h.p. at 375 r.p.m. The detailed construction of these models is described in brochure No. 8102, issued by Ruston & Hornsby Limited, of Lincoln, and a range of 10 larger vertical engines for which Büchi pressure-chargers are regarded as standard equipment, are dealt with in publication No. 8140. These engines vary in output from 415 to 1,560 b.h.p. at 600 to 375 r.p.m., but only the three or four smallest models are suitable for locomotive work.

DIESEL TRAIN OPERATION ON THE SANTA FE

A brief account of the express trains over medium and long distance routes hauled by diesel locomotives on one of the leading American railroads

SHUNTING locomotives excluded, diesel operation on the Atchison, Topeka & Santa Fe Railroad began in the autumn of 1935 with a square-ended twin-unit double-bogie locomotive of 3,600 b.h.p. After lengthy experimental and regular operation of this locomotive on express passenger trains, principally on the then new Super Chief train between Chicago and Los Angeles, a programme was drawn up for the construction of new diesel-electric locomotives and trains for express services, and the first of these was introduced in the summer of 1937. The Santa Fe now has nine such train sets operating five distinct services at schedule speeds of 52·8 to 60 m.p.h. over distances varying from 126 to 2,228 miles, with an aggregate mileage to date exceeding 3,250,000. The number of passengers carried appreciably exceeds 1¼ million, although two of the nine trains are *de luxe* only, and others have observation and parlour cars.



One of the 1,800 b.h.p. Electro-Motive diesel-electric locomotives used for the haulage of El Capitan, the Golden Gates and other A.T.S.F. express trains

The Super Chief

The Super Chief was introduced on May 12, 1936, on a 39¾-hr. schedule between Chicago and Los Angeles, although all the contemplated track works had not then been completed. It was unusual only in having a diesel locomotive, for the seven cars in the train were of standard heavy type, and the complete train including locomotive weighed 820 Engl. tons. Although the much slower steam-hauled Chief was then running with relatively small traffic, the Super Chief almost at once was booked nearly to capacity, and continued so. On May 18, 1937, a new nine-car stainless steel train and blunt-nosed 3,600 b.h.p. diesel-electric locomotive were introduced on the same schedule, after having made a special run from Los Angeles to Chicago in 36 hr. 49 min. The passenger capacity was somewhat greater than in the first formation, but it was booked to capacity regardless of the season. A second train of the same type was brought into traffic on February 20, 1938, and the original locomotive and train were then withdrawn.

Each of these extra-fare trains now makes one round trip of 4,456 miles a week, the end-to-end speed in each direction being 56·6 m.p.h., despite grades of 3·3 to 3·5 per cent. between La Junta and Isleta, and others of 1·4 to 2·2 per cent. between Los Angeles and Winslow. Curves are as sharp as 11 deg. (530 ft.) on the mountain section, but do not exceed 6 deg. (960 ft.) on the remainder of the line. About 80 per cent. of the whole route is straight and 65 per cent. is double track. Rails are 90 to 131 lb. sections.

The present trains comprise one club-baggage car, one club-lounge car, one diner, five sleeping cars, and one sleeper-observation car weighing 460 Engl. tons. The locomotive weighs 256 Engl. tons, giving a total train weight of 716 tons. Eight of the cars in the first train are of the Budd stainless steel type and the other a Cor-Ten steel Pullman car sheathed with stainless steel; in the second train three cars are stainless steel and six are of Cor-Ten steel with stainless steel sheathing. The average centre of gravity height of the cars is 55 in., and the overall length of the train including locomotive is 891 ft., most of the cars being 79 ft. to 83 ft. long. Accommodation is provided for 121 through passengers, but in addition to this number of berths there are 36 dining-car seats and 77 lounge seats.

From the first to the second year of service the revenue

The eight-car stainless steel Super Chief de luxe train of the Atchison, Topeka & Santa Fe Railroad, hauled throughout between Chicago and Los Angeles by a twin-unit 3,600 b.h.p. Electro-Motive diesel-electric locomotive. The 2,228 miles are covered in 39¾ hours

earned by the two present stainless steel trains increased from $437,000 to $794,358, and over that period the operating cost (exclusive of financial charges) was only 35 per cent. of the revenue. The revenue per train-mile was $2·514. Operating expenditure per train-mile was made up of 30·8 cents wages of crew, 10·2 cents fuel, 2·8 cents lubrication and supplies, 10·4 cents train supplies and expenses, 22·3 cents power plant maintenance, 8·3 cents train maintenance, and 3·5 cents loss on dining-buffet service, or a total of 88·3 cents. The revenue of $2·514 a train-mile is the railroad company's revenue; in addition there is also the Pullman company's revenue. Over two years—actually from June 15, 1937, to June 1, 1939—the train miles run on the Super Chief service totalled 748,568, the number of passengers carried 28,933, the passenger miles 60,086,144, and the average revenue per train-mile was $2·22; it is to be noted again that the operating expenses took only 67·7 cents, or 40 per cent., comprised of 27·8 cents crew wages, 5·8 cents fuel, 1·6 cents lubrication and supplies, 7·9 cents train supplies and expenses, 8·9 cents power plant maintenance, 11·8 cents train maintenance, and 3·9 cents loss on dining-buffet service—total 67·7 cents. The average receipts have risen since that time, and for the period of nearly 18 months from February 22, 1938, to June 1, 1939, the average receipts were $1·82. In the same period the number of passengers carried was 35,100, the train-miles 587,875, the passenger-miles 60,033,597, and the average number of passengers per train 102.

The diesel-hauled Super Chief being piloted over the mountain section west of La Junta by a 2-10-2. *steam locomotive. All trains, whether diesel or steam, are double-headed over the grades of* 3·5 *per cent. westbound and* 3·3 *per cent. eastbound*

second train did not begin to operate until February 20, 1938, so that the aggregate service is equivalent only to about 3½ train-years.

El Capitan

These two sets were the first high-speed coach (*i.e.* ordinary passenger) trains running between Chicago and California. They operate over the same route as the Super Chief and make the same mileage, each train running one return trip a week on a 39¾-hr. schedule. They were placed in traffic on February 22, 1938, and up to June 1 last had covered an aggregate of 587,875 miles.

Each train normally comprises an 1,800 b.h.p. double-bogie diesel-electric locomotive weighing 132 Engl. tons hauling five Budd stainless steel cars weighing about 225 tons, and having a capacity of 156 coach passengers plus 38 dining and 32 lounge seats. Ordinary coach fares and a small supplement are charged. The composition of the train is one baggage-dormitory-chair car, two chair cars, one chair-observation car, and one lunch counter-dining car. Owing to the heavy demands for accommodation, particularly in the summer season, one new 1,800 b.h.p. diesel locomotive, one extra dining car and three extra coaches have been built, and at periods of heavy traffic the formation is increased by a diner and by two or three chair cars as required. If more than two vehicles are added the extra 1,800 b.h.p. locomotive is brought into use for double-heading.

Over the first six months of operation the receipts from El Capitans averaged $1·701 per train-mile, and of this

Other Trains

The three remaining fast diesel-hauled services (five trains) on the Santa Fe comprise a seven-car (originally six-car) stainless steel train drawn by an 1,800 b.h.p. locomotive and running over the 128 miles between Los Angeles and San Diego in 2½ hr.; two seven-car (originally five-car) stainless steel trains drawn by an 1,800 b.h.p. locomotive and running at an average of 56 m.p.h. between Oakland and Bakersfield (connections for San Francisco and Los Angeles); and two six-car sets hauled by the same type of locomotive and running between Chicago and Kansas City at a mile-a-minute average. The first train, the San Diegan, went into traffic on March 23, 1938; the second, the Golden Gates, on July 1, 1938; and the third—the Chicagoan and Kansas Cityan—on April 17, 1938. Up to June 1 last, the two Chicago—Kansas City trains had between them carried 164,503 passengers, run 556,780 miles, and averaged $1·68 per train-mile revenue; operating expenses are believed to be 75 to 80 cents a train-mile. The Golden Gates trains up to June 1 last carried 214,562 passengers, ran 419,420 miles, and averaged $1·39 a train-mile revenue; the San Diegan's figures were 229,778 passengers, 217,424 miles and $1·69 a mile revenue.

The 1,800 b.h.p. diesel-electric locomotives used on these trains form good examples of modern American main-line practice. Although housing two General Motors (ex-Winton) two-stroke engines weighing 20 lb. per b.h.p., the complete locomotive weight is only 147 U.S. tons (132 Engl. tons). In the latest units the weight has been reduced to about 140 U.S. tons (125½ Engl. tons), equivalent to 155 lb. per b.h.p. Using the new General Motors 1,000 b.h.p. engine, the weight of a 2,000 b.h.p. locomotive is very little greater.

FUEL STORAGE FOR DIESEL RAIL VEHICLES

By G. W. McARD

NO really satisfactory and permanent scheme of fuel-oil storage for a diesel traction depot can be decided upon without consideration being given at the same time to the manner in which the oil in the vehicle tanks will be replenished. These vehicle tanks may be filled by the employment of gravity, a vacuum, compressed air, or a force pump—hand or power operated. If gravity filling is chosen, the depot tanks will be elevated suitably with reference to the maximum height of the vehicle tanks which are to be filled. On the other hand, if one of the other methods of filling is employed, tanks can be situated at ground level.

A simple layout for depot storage comprises one or more cylindrical tanks placed with their axes inclined sufficiently to facilitate the settling of sludge to one end, whence the deposit is periodically drawn off through drain cocks of large bore, preferably of the gate type. On the top of each tank a manhole seating and cover is provided, the former welded in position and the cover fixed by square-necked studs having nuts locked by wire and a lead

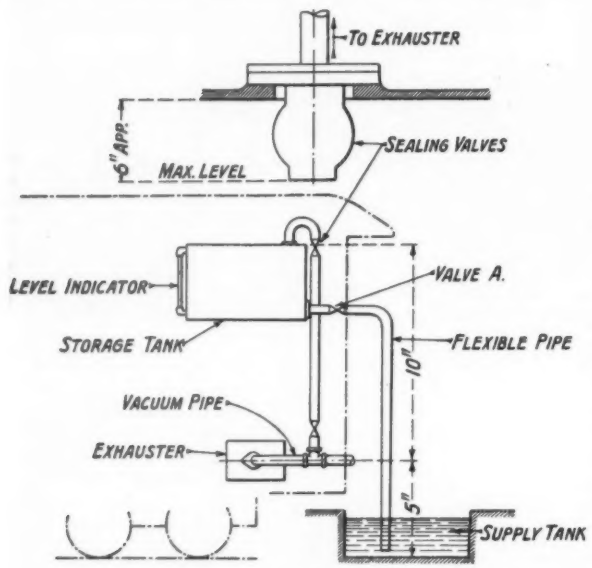


Fig. 1—Diagram showing principle of filling fuel tanks by vacuum

seal. Into the cover two pipes are screwed and welded to guard against tampering; one of them is used for filling the tank and the other for venting the air as the oil level rises. As the cap for the filling pipe must be removable from time to time, it must be secured by a padlock.

The emptying pipes are led from a suitable point on the tank end opposite to that at which drainage occurs, and these pipes, with the requisite cocks, are so arranged that the fuel will pass through a water trap on its way to the vehicle tanks. A hand pump or small electric motor, as may be preferred, transfers the fuel to the vehicle tank, and if required can also be used for transferring the fuel oil from the rail tanks to the storage containers. This layout is one which can be extended to a very large capacity, and the principles embodied are such as would apply to any scheme, apart altogether from its size, thus providing a battery of large-volume tanks which would ensure a rapid, efficient and clean method of oil fuelling for either locomotives or railcars.

For gravity filling the above principles still hold, *i.e.*, trapping of sludge and moisture, venting, filling and so forth, and the layout described can be employed as a base for designing any scheme required. A final word is necessary, especially where native labour is concerned: the reliability of the man in charge of the depot, and his assistant, must be absolutely beyond question, and they jointly must be held fully responsible for seeing that under no circumstances whatever can the fuel be tampered with. Too many instances are to hand of services being entirely dislocated through the surreptitious addition of sand or water to the storage tanks.

Methods of Transfer

Turning now to the consideration of the actual transfer of the oil to the tanks of the railcar or locomotive itself, the alternative methods available may be summarised as:—

(1) Gravity.
(2) Vacuum.
(3) Compressed air.
(4) Force pump.

Gravity.—Employing gravity as the agent is the simplest method, and needs little further comment than has already been made, the storage and vehicle tanks being placed in communication with each other, and the requisite quantity of oil passed to the vehicle. Measurement of the amount taken may be effected by a flow-meter or other similar device, and when the tank is full—filling takes only a few minutes with the largest capacity tanks yet fitted—the vehicle clears the track for the next comer. The whole operation is vastly superior to that obtainable with the most modern of coal-bunkering depots.

Vacuum.—Although the filling of the vehicle tanks can be carried out quite well by utilising the vacuum exhauster—this being a standard item of equipment on locomotives or other units operating vacuum-braked stock—no user appears to have had the courage to adopt the scheme. The reason for the reluctance may be the provision which has to be made for connecting the vehicle fuel tank to the exhauster. Normally, on starting the exhauster and after opening the valve *A* (Fig. 1) on the oil-supply pipe line, the vacuum created lifts the oil and so fills the tank. The objection lies in the possibility of an overflow of oil to the exhauster and the vacuum pipe line, but an effective safeguard may be provided by the fitting of a sealing valve inside the vehicle tank and immediately beneath the inverted bend at the top of the pipe connecting to the exhauster. The tank itself must be designed to withstand the resultant external loadings that will occur when the vacuum is created and filling commences.

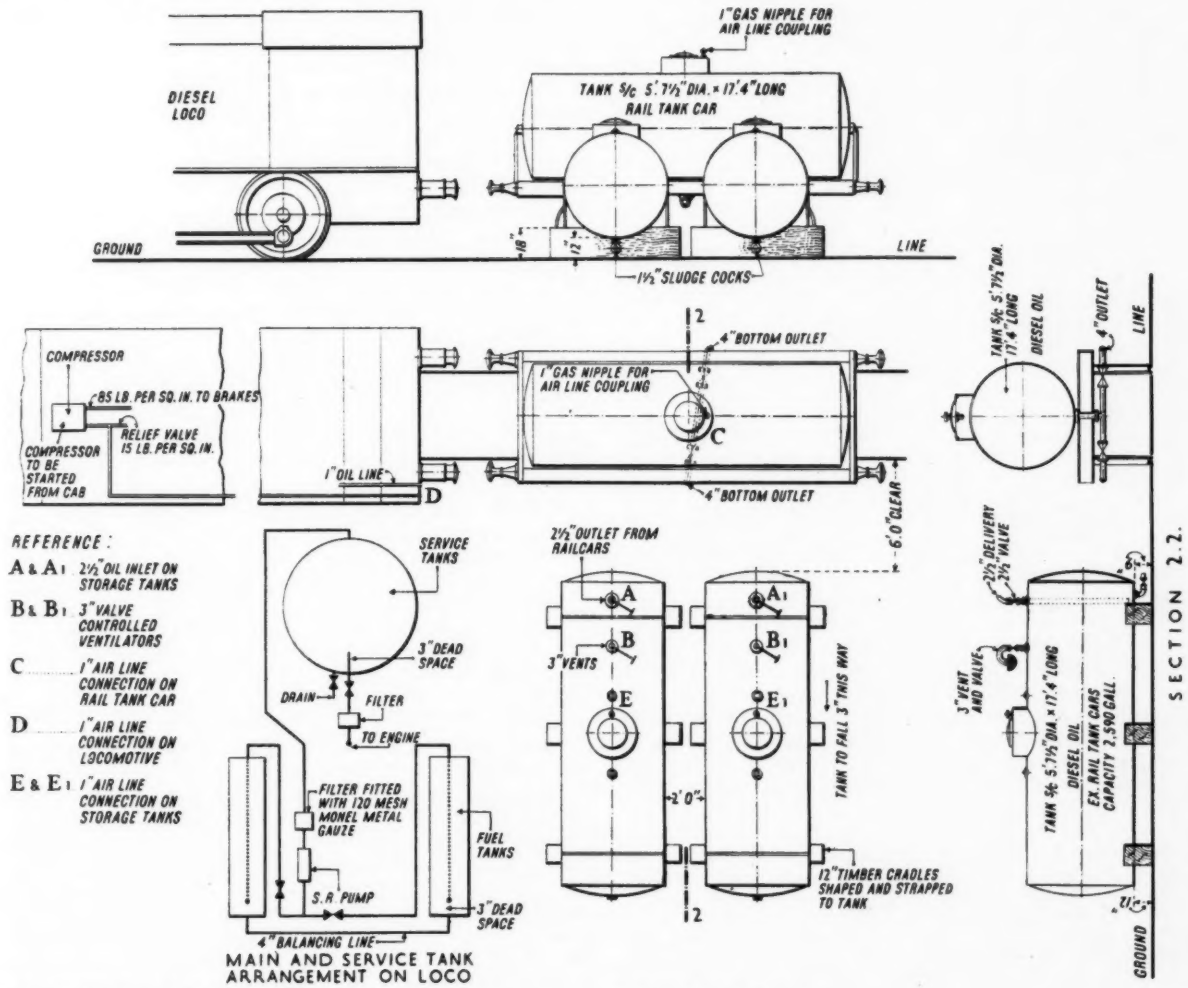
Compressed Air.—The use of compressed air for tank filling has already been successfully tried out, and a leading instance of this is provided in the fleet of heavy diesel-electric shunting locomotives on the L.M.S.R. Fig. 2 shows a layout with a pair of ex-rail tanks giving a combined capacity of slightly over 5,000 gal., a rail tank, and a locomotive, each with air and oil pipe lines. The sequence of operations is: connecting the locomotive

air supply to the rail tank and the oil-pipe on the latter to the fixed depot tanks, the admission of air to the rail tank empties the contents of this unit and at a later stage, when the rail tank is cleared for further duty elsewhere, the locomotive storage tank is filled by passing air to the ground tank. With such a scheme as this, careful consideration needs to be given to the pipe arrangement generally, as well as to the provision of suitable traps and emptying cocks for condensate, but the operation of filling is easily controlled, and where a good supply of air is available the proposition is attractive. The air pressure used is often reduced from the standard of 80-90 lb. per sq. in. for brake operation to approximately 15 lb. per sq. in., but the pressure actually employed has been found on the L.M.S.R. equipments to be as low as 3 or 4 lb. per sq. in.

Force Pump.—If a pump is selected as the most suitable means of filling, the question of hand or mechanical power will be determined by the capacity of the tanks to be filled, as well as by the frequency of filling. A further decision must be made as to whether the pump shall be permanently mounted at the depot or carried on the vehicle, and where filling is done by a power-operated pump the latter scheme appears to be that most in favour. Such a layout has the filling pipes across the vehicle for attachment at either side to the depot tank, and thence to the vehicle tank through the filter at the upper end of the delivery pipe; a small priming hand pump is fitted to ensure the motor-driven unit coming into effective operation with a minimum of lost time.

Level Indicators

A device that is frequently employed on the larger schemes is the float switch. The switch is used as a tell-tale or warning when the level of the liquid reaches a predetermined danger point, but the method of operation remains the same whether used for oil or water. On switching in the pump, or connecting to the overhead supply tanks in the case of gravity filling, the oil commences to rise in the vehicle tanks, and on reaching the



MAIN AND SERVICE TANK ARRANGEMENT ON LOCO

To Transfer from Storage to Fuel Tank on Locomotives :—
Couple 1½-in. flex delivery hose to point A and insert filter end in tank fill points.
Couple 1 in. flex air hose to D and E.
Open valve A and apply air pressure, making certain vent valve B is closed.

Hoses—Greenwood E Armoured :—
Air Line.—1 flex to stand 30 lb. per sq. in., cap and liner each end.
Railcar Discharge.—2½-in. flex, 2½in. cap and liner each end.
Fuelling Transfer Hose.—1½-in. flex, 2½-in. cap and liner each end.
1½-in. Zwicky quick-release filter with 120 Monel metal and 1½-in tip.

To Empty Railcar to Storages :—
Open valve on vent B.
Couple 2½-in. hose to railcar bottom outlet, and A and 1-in. air hose to D and C.
Open foot valve in railcar and plug cock.
Open valve A and apply air pressure to railcar ; air pressure from locomotive taken direct from compressor at a maximum pressure of 15 lb. per sq. in. controlled by automatic regulator.
On completion of discharge of railcar, disconnect hoses after closing all valves.
A 4-in. female and 2½-in. male adaptor will be available for use with the railcars.

Fig. 2—Fuelling arrangements with compressed air filling

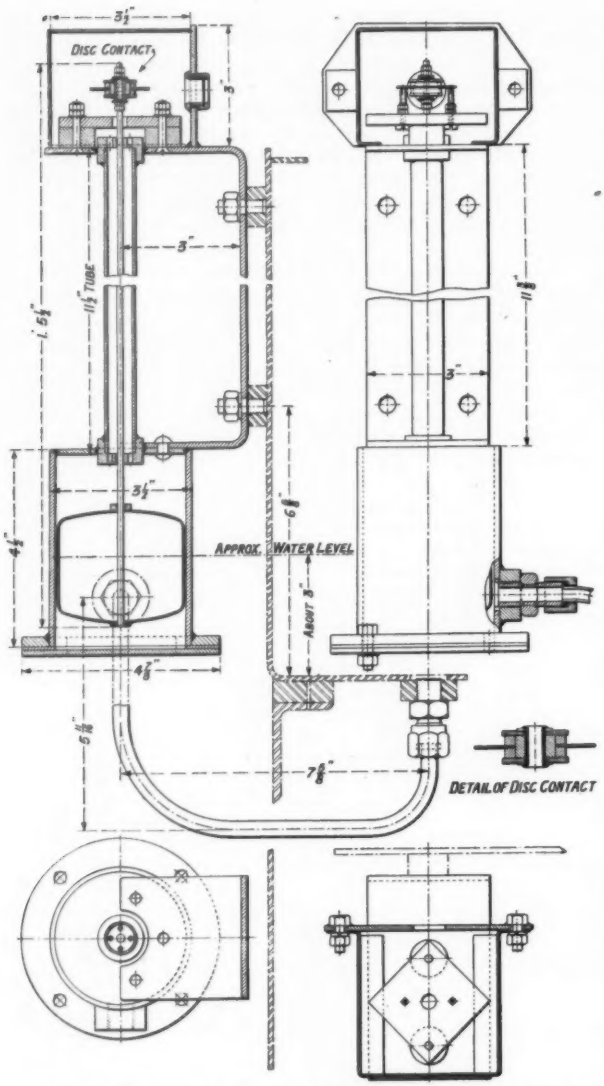


Fig. 3—Float switch as used for indication of fuel level

required height—or preferably an inch or so below this point to allow for the inertia of pump—the rising float closes the circuit and switches off the pump motor, or, in the case of the gravity feed, closes the supply cock by means of a solenoid or e.p. valve. If desired, a bell can be introduced into the circuit to call the attention of the staff.

Fuel Overflow

While small railcars may have but a single tank of comparatively low capacity, the larger cars may carry a big tank or pair of tanks, and a smaller tank for service purposes. The latter is usually kept supplied by a constant flow of oil transmitted from the main tanks by a transfer pump operated by the main engine itself. Where a separate engine is employed for the auxiliaries, the pump would be controlled by the smaller power unit. In most schemes, any excess of oil in the service tanks is led back to the main tanks by way of an overflow pipe, but as the difference in height of the outlet on the service tank and the inlet on the engine fuel pump is usually small, due to loading gauge restrictions, several schemes are now in operation whereby the excess fuel from the service tank can only escape to the main tanks by a pressure by-pass, thus raising the pressure of oil in the service tank and obtaining in effect the equivalent of a greater head to the engine fuel supply.

In many vehicles the device for measuring the contents of the tanks has given a considerable amount of trouble. This accessory may take the form of an improved type of water gauge glass, a float gauge, or an instrument in which an air chamber is employed. With the third method the pressure set up by the head of oil in the tanks is registered through the medium of a disc of cellophane in the chamber, on a dial situated in any predetermined position on the vehicle. The best type seems to be the Malone gauge, and it is being tried out at present on some high-powered units for an important South American railway.

Notes and News

Italian Diesel Cars.—In the course of the year ending June 30, 1939, the Italian State Railways put into traffic 50 new diesel railcars.

Walker Railcars.—Among the diesel railcars under construction at the works of Walker Bros. (Wigan) Ltd. are a bogie vehicle for the Trujillo Railway, in Peru, and a power bogie and equipment for the County Donegal Railways.

French Railcar Proposals.—M. Jean Lévy, Directeur du Service Central du Matériel of the French National Railways stated recently that endeavours were being made to evolve for the S.N.C.F. a standard railcar to run at a top speed of 75 m.p.h. and which would haul 50 tons of trailers at 60—62 m.p.h.

Methane Railcars.—The Italian State Railways are experimenting on the Bologna-Milan section with railcars driven by methane gas, the engines being modified from standard diesel types. Experimental Ansaldo cars with charcoal-burning producer-gas plants are being run between Genoa and Milan.

G.W.R. Railcars.—Railcar services, which were suspended by the Great Western Railway after the outbreak of war, are being gradually reintroduced, and there are now services in the Thames Valley, and—on Mondays and Fridays—between Birmingham and Cardiff. Construction of the 20 new A.E.C. diesel railcars is still proceeding. On the L.M.S.R. the 95 b.h.p. Leyland four wheelers are operating on the Blackburn-Clitheroe line and between Hamilton, Holytown and Brocketsbrae in Scotland, on both of which routes they have operated for some time. At the moment, the 720 b.h.p. three-car diesel train is out of service for overhaul.

Argentine Railcar Service.—According to the report of the Buenos Ayres Great Southern Railway for the year ending June 30 last, the mileage of the diesel railcars in that period increased by 698,321 km., this being due to the gradual introduction of the 99 Drewry cars, most of which are in traffic in the Buenos Aires district. The results so far obtained show that the considerable economy is derived from the use of diesel railcars instead of steam trains on the outer suburban services. To combat competition in the Bahia Blanca district an experimental service with petrol railcars was commenced on May 1 last, with a reduced one class fare, and results so far have been satisfactory. The one-class railcar service Cañuelas-Lobos-Navarro continues to attract passengers, an increase of no less than 25 per cent. in the number carried having taken place during the year.

Diesel Railway Traction

Some Notes on Braking

IN the braking of trains, Newton's fundamental laws apply to a degree which is met but infrequently in other branches of mechanical engineering, although, particularly in the retardation of high-speed trains, the operation is full of complex variables existing for very short spaces of time. For example, in accordance with the second law, the retarding force is equal to the mass multiplied by the retardation. If the retarding force is equal to the weight being braked, the retardation is *g*, or 32·2 ft. per sec. per sec., equivalent to a deceleration of 22 m.p.h.p.s., the attainment of which would be much more uncomfortable to the passengers than the actual rate itself when once attained. A braking force of 20 per cent. of the mass is equivalent to 4·4 m.p.h.p.s. As the braking force cannot be internal, but must be external to the train or vehicle, it is through the medium of the rail and the friction of the wheels on it that the force through the brake shoes is made effective. The retarding force is at a maximum when the wheels roll freely, as the friction between them and the rail is then at its top value, whereas when the wheels slide the friction is reduced. With high-speed trains it is essential to maintain the same relative braking forces on each pair of wheels, and neither this nor the engineering problems of force application and heat dissipation are easy of solution when instantaneous torces equivalent to something like 2,000 h.p. per axle, or 500 h.p. per brake shoe, are involved. To apply maximum retardation rates at the highest speeds is one of the cardinal principles of quick stops, and most test records show that when the speed has been reduced by half about 80 per cent. of the stopping distance has been covered. A second cardinal principle is to apply the brakes as quickly as possible, a delay of one second at 100 m.p.h. meaning another 147 ft. on to the stopping distance. The problem is made more difficult because up to the present it has proved impossible to build up a braking force of 200 per cent. with cast iron tread blocks in less than three seconds.

The Future of the Two-Stroke Engine

FROM time to time since this Supplement began, we have expressed the belief that eventually the two-stroke engine would have to be adopted in order to make full use of available space and weight. Hitherto the difficulties, physical and mechanical, associated with two-stroke engines have prevented any advantage being gained compared with four-stroke types, always excepting the remarkable C.L.M.-Junkers engine, which in its rail traction forms can operate at speeds up to 2,100 r.p.m. in conjunction with unit weights of less than 10 lb. per b.h.p., and which in road transport applications gives up to 35 b.h.p. per litre of piston-swept volume when running at 3,000 r.p.m. But the coming of the long-awaited Messiah of ordinary two-strokes appears to be at hand, in the form of the Kadenacy principles. Like many great developments, it is simple in the extreme, and in these days of inverted values this very simplicity may prevent a wide adoption, for it requires the manufacture of no extraneous equipment. The investigations of Mr. Kadenacy, first in France and subsequently in England, were based to some extent upon ballistics, and sought to make use of the explosive effect of exhaust gases when the exhaust valve or port was opened suddenly. The body of exhaust gas has a velocity in the direction of the open port which predominates over the co-existent expansion in all directions, and for all practical purposes the mass of exhaust gas can be made to leave the cylinder within an extremely short time, the incoming fresh air charge following it, and a portion even being drawn through the exhaust opening. The exhaust port is closed before the return-wave effect of the exhaust occurs, and the principle of making exhaust and intake two separate but interdependent processes is in direct opposition to the hitherto prevailing tendency to mix up fresh air charge and burnt gases as thoroughly as possible, in the belief that the fresh air had to sweep out an exhaust which was almost inert. As described elsewhere in this issue, the application of these Kadenacy principles to normal two-strokes—some with poppet valves, some with the cumbersome piston-controlled intake and exhaust, and others of the already efficient opposed-piston type—can give a considerable improvement in engine performance without increasing the temperatures or working stresses, giving operating m.e.p.s at least equal to those of a top-class four-stroke, and realising the dream of twice the power for equivalent speed and weight.

With every copy of this issue is presented an index for the Diesel Railway Traction Supplemeuts from January 20 to December 22, 1939.

Diesel Traction in Madagascar

ALTHOUGH it had been intended to work the Fianarantsoa—Manakara (East Coast) line of the Madagascar Railways by diesel traction from its opening in 1936, actually no decision was made as to the form of the units within reasonable time of the opening, and therefore five Mallet steam locomotives were ordered and delivered quickly in order to work the first traffic. Since that time two diesel-electric railcars and three triple-bogie diesel-electric locomotives have been delivered for this 100-mile metre-gauge line, which has grades as steep as 1 in 29, curves as sharp as 80 m. (262 ft.) radius, and altitude ranging from sea level up to 1,086 m. (3,570 ft.). The railcars are of the Brissoneau & Lotz type, and are equipped with two six-cylinder Saurer BXD engines set to give individual outputs of 150 b.h.p. at 1,500 r.p.m. up to the maximum altitude; the attainable speed is 85 km.p.h. (53 m.p.h.) on the level and 34 km.p.h. (21 m.p.h.) up the steepest grade. On a tare weight of 31½ tons are provided 6 first class, 16 second class and 20 third class seats. The locomotives are of the Bo-Bo-Bo type, weighing 66 tons, and this elongated pattern of wheel arrangement was necessitated by the low permissible axle load. Power is furnished by a pressure-charged Sulzer 6LDA25 engine giving 625 b.h.p. at 735 r.p.m.; loads up to 180 tons can be hauled up the 1 in 29 from the sea and 270 tons in the opposite direction, in which the maximum grade is 1 is 40 for a short distance.

XUM

THE NEW GREAT WESTERN RAILCARS

The construction of these 20 vehicles is now well advanced, and trials with single cars and two sets coupled in multiple-unit have been carried out on the Southall-Brentford line

THAT the Great Western Railway in conjunction with the A.E.C. should be pushing on fast with the 20 diesel railcars ordered in 1938 says a good deal for the merits of diesel traction under conditions such as those now existing. The principal advantage from the railway company's point of view is that the new cars are all trailer-hauling, and can replace steam trains on services with little revenue and yet keep within the supply of imported oil fuel.

Floor plans of the seating arrangements were reproduced in the issue of this Supplement for May 12, 1939. Four of the cars are to be arranged as twin-coupled sets with vestibule connections between the two vehicles, and will have a top speed of 70 m.p.h. They are intended to replace the existing single-unit cars on the Birmingham—Cardiff service. One car is being fitted up solely for parcels traffic, and the remaining 15 vehicles are for branch line and subsidiary services. Of these 15 cars two are being given dual-range gearboxes to provide alternative top speeds of 60 and 40 m.p.h.; the others are geared for a top speed of 40 m.p.h. and are designed to haul trailing loads up to 60 tons. Electro-pneumatic multiple-unit control is incorporated in all cars.

Improvements in Design

In general, the design of the mechanical portion is based upon that of the trailer-hauling railcar No. 18, which has operated so successfully on the Lambourn Valley branch, but the contour of the new cars, particularly at the ends, differs from those of the preceding 18 A.E.C. railcars on the G.W.R. Compared with No. 18 car, the principal differences are:—

Engines staggered and moved outwards towards the bogies, instead of being mounted opposite to one another at the mid-length of the chassis.

Detail modifications to the side mounting and engine suspension.

New type of engine with improved oil-cooling arrangement.

Radiators carried behind engines, at mid-length of chassis, and fitted with intermediate header tanks for de-aeration.

Cooling by two fans per radiator.

Axleboxes re-designed with S.K.F. roller bearings.

Two tread brake shoes to each wheel, in place of internal-expanding brakes.

Hydraulic shock absorbers of the piston type, instead of the previous disc pattern.

Electro-pneumatic controls with new design of preselector.

Self-contained control table.

Single-lever shunting controls at each side of the driving cabin.

Improved layout of control wiring.

Engine Equipment

The engine now used is of the A.E.C. direct-injection type, to give maximum possible fuel economy. The six cylinders are 120 mm. by 142 mm. and the engine is set to give 105 b.h.p. at 1,650 r.p.m. compared with the maximum output of 120 b.h.p. at 2,000 r.p.m. of the earlier 115 mm. by 142 mm. engines with Ricardo heads. Compared with the standard A.E.C. road transport engines, the previous railcar units had an enlarged sump to give better oil cooling, but a further improvement has been made in cooling the oil by passing it over water-cooled grids in the big sump; the water itself is cooled by circulating through the outer bank of gilled tube elements in each radiator, and water passing in series through the elements. The radiators themselves are carried on rubber cushions mounted on brackets cantilevered from the main underframe members. The cooling is by two fans per radiator, mounted directly on a fixed countershaft forming part of the transmission cardan shaft line. Each countershaft has a belt drive to a dynamo and two exhausters. Every car of the 20 is equipped with two engines, giving an aggregate output of 210 b.h.p.

Transmission

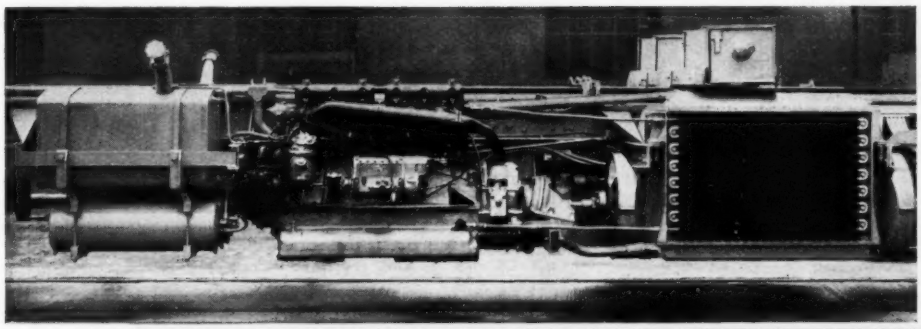
The transmission is on the same general principles as adopted for previous A.E.C. railcars, and comprises, down each side, a fluid flywheel, cardan shaft, Wilson epicyclic gearbox, cardan shaft, and bevel axle-and-reversing gears on the end of the inner axle, and a cardan shaft and bevel drive to the outer axle of the bogie. The five-speed gearbox has ratios of 6·38, 4·5, 2·53, 1·64 and 1·0 to 1, and the axle bevels 2·59 to 1. The auxiliary gear reductions are 0·919 to 1 for the twin-car express sets, and 1·63 to 1 for the single-unit cars; the dual-geared cars have auxiliary gear ratios of 1·09 to 1 (high) and 1·63 to 1 (low). The electro-pneumatic remote control is designed to give definite movements for all motive power equipments under the control of the driver, irrespective of the air pressure available; the preselector motor is of a simple but ingenious design to give the five positions with only three moving parts. The magnet valves for each side are grouped in a very accessible position near the radiator, and are enclosed in a casing with a hinged drop cover. The dual-range cars have 11 magnet valves and the single-range cars nine. To avoid cross connections, jumper couplings are fitted to all four corners of each railcar, and are symmetrical about the centre line. For shunting purposes a switch, normally closed, is inserted in the control, to allow the necessary operations to be effected with the driver leaning out of the window at either side.

The new cars have 38-in. wheels spread over a bogie wheelbase of 8 ft. 6 in.; the bogie pivots are pitched at 43 ft. 6 in. centres and the car length over headstocks is 62 ft. Curves of a minimum radius of 3½ chains can be negotiated. The single cars have 48 third class seats and the estimated tare weight is 35 tons. The twin-car sets have a buffet, and lavatory, and provide seating accommodation for 104 passengers.

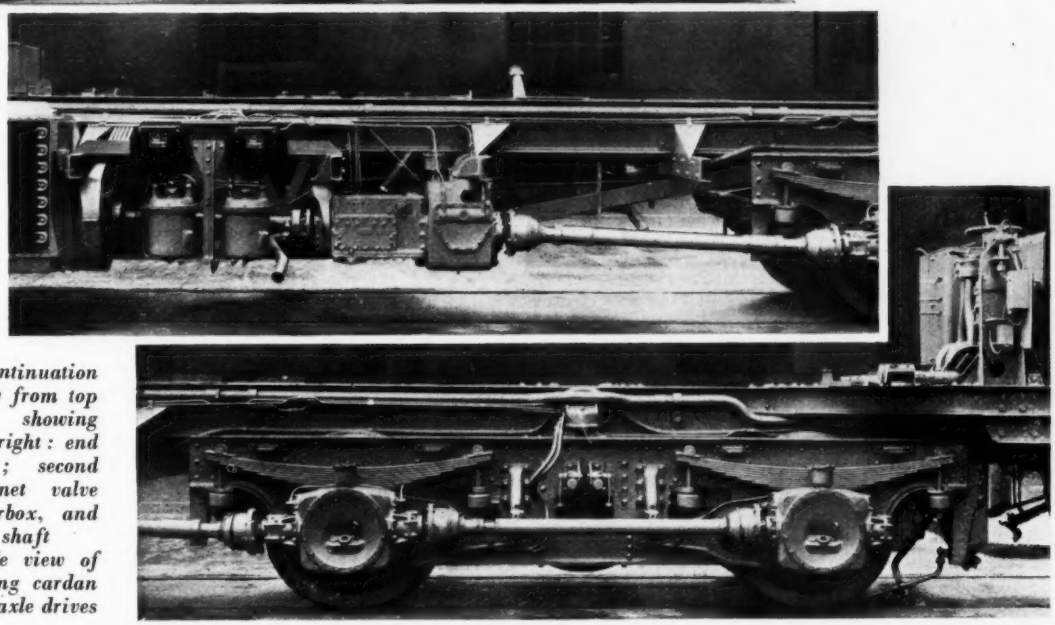
Accelerations

The twin-car sets are geared to give top speeds of 11·8, 16·8, 29·9, 46·1, and 75·5 m.p.h. on the respective gear steps; the single-unit single-ratio cars 6·7, 9·4, 16·8, 26·0, and 42·5 m.p.h.; and the dual-geared cars 10·0, 14·1, 25·2, 38·8, and 63·7 m.p.h. on high gear and 6·7, 9·4, 16·8, 26·0, and 42·5 on low gear. Maximum tractive efforts are 11,380 lb. in first and 1,840 lb. in top for the twin cars; 10,060 lb. in first and 1,630 lb. in top for the single unit cars and in low ratio for the dual-geared vehicles; and 6,720 lb. in first and 1,090 lb. in top for the dual-geared cars when operating on the high ratio.

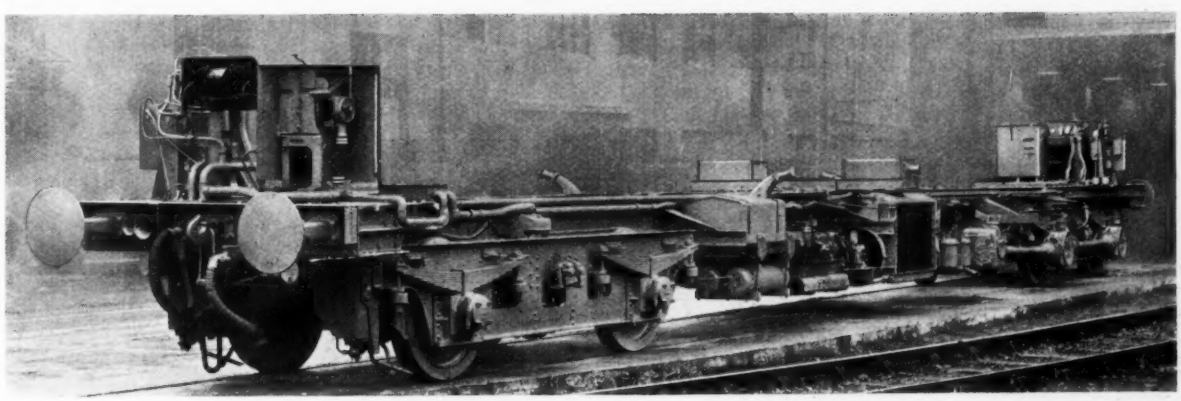
Along the straight level the twin-car sets accelerate from rest to 20 m.p.h. in 27 sec., to 30 m.p.h. in 57 sec., to



Left: Side view of part of chassis showing, left to right: fuel tank and air reservoirs: new A.E.C. engine; fluid flywheel; fan; and radiator with auxiliary water tank above



Above: Continuation of side view from top illustration showing from left to right: end of radiator; second fan; magnet valve boxes; gearbox, and cardan shaft
Right: Side view of bogie showing cardan shafts and axle drives



Chassis of twin-engined A.E.C. diesel-mechanical railcar for the Great Western Railway, as it ran trials on the Southall-Brentford branch. Between the left hand buffer and the brake pipe can be seen one set of Desilux horns

40 m.p.h. in 95 sec., to 50 m.p.h. in 170 sec., to 60 m.p.h. in 285 sec., and to 70 m.p.h. in 490 sec., and a distance of about seven miles. The single-unit single-ratio cars can accelerate from rest to 20 m.p.h. in 28 sec., to 30 m.p.h. in 55 sec., and to 40 m.p.h. in 92 sec., and within a distance of about 0·62 miles. Operating in high gear, the dual-ratio cars attain 20 m.p.h. in 26 sec., 30 m.p.h. in 54 sec., 40 m.p.h. in 98 sec., 50 m.p.h. in 176 sec., and 60 m.p.h. in 300 sec., and within a distance of about 3·6 miles. Hauling 60 tons of trailers, the acceleration of the single-unit cars is to 20 m.p.h. in 68 sec., to 30 m.p.h. in 170 sec., and to 40 m.p.h. in 336 sec. Already a number of chassis have been tested out on the Brentford branch of the G.W.R., operating solo and in multiple-unit, and as bodies are finished at Swindon, further tests with complete railcars will be undertaken.

Diesel Train Operation in Australia

Brief notes on the two years' work of the New South Wales long-distance sets

IN September, 1937, the first of five diesel-hydraulic power vans and passenger trailers was put into traffic on the New South Wales Government Railways, and the remainder followed shortly after. A complete train comprises a 720 b.h.p. power van, a first class trailer, a second class trailer, and a parcels van, as described in the issue of this Supplement for October 29, 1937. The motive power equipment in each van consists of two eight-cylinder Harland & Wolff two-stroke engines driving individual sets of Voith-Sinclair hydraulic transmission. These power units are located end-to-end in the centre of the power car, and are started by air. They have a continuous rating of 330 b.h.p., and were described and illustrated in the January 22, 1937, issue of this Supplement.

Track Conditions

These trains operate over the line between Parkes and Broken Hill, a distance of 422 miles. In the first two years of operation until September last, the five power vans had covered a mileage in excess of 450,000, equal to more than 45,000 miles per van a year, as all five units were not introduced at the same time. From Parkes to Condobolin, a distance of 63 miles, the track is laid with 60-lb. rails and has ash and earth ballast. Maximum speed over this section is limited to 50 m.p.h. Between Condobolin and Broken Hill the track is laid with 80-lb. rails, and although only earth ballast is used these diesel trains are allowed to run up to 70 m.p.h. Over the 359 miles from Condobolin to Broken Hill the average running speed is 50 m.p.h., and this can be considered as quite good in view of the ballasting and the unfenced condition, which leads to numerous slowings. Over the Condobolin—Parkes section the average running speed is 35 m.p.h.

A train crew consists of a driver, diesel fitters, a guard, and a buffet attendant. The construction and maintenance of the trains comes under the Rail Motor Section, a department of the N.S.W. Government Railways, which has been in existence for nearly 20 years. The staff selected from the Rail Motor Section to maintain these diesel trains in service was used to construct the mechanical portions of the power vans and instal the engine and transmission equipment, and therefore gained a good knowledge of the complete design.

The running cost of a four-car train is 2s. 4d. per train-mile, and this sum includes all charges of the traffic and locomotive departments with the exception of interest and depreciation. In this figure are included general overhaul charges of 6d. a mile for the diesel power van; 1¼d. a mile for the first class trailer; 1½d. a mile for the second class trailer; and ½d. a mile for the parcels van.

Motive Power Performance

Mr. Harold Young, Chief Mechanical Engineer of the New South Wales Government Railways, to whose design the trains were built, tells us that the main diesel engines have given reasonably good service, although experience gained in their operation has suggested that improved cooling to pistons and cylinders would result in an even more satisfactory performance. Regarding the hydraulic transmission sets, Mr. Young says that definitely no trouble has been experienced with any of the units, and that the oil used or lost through leakage is negligible.

A four-car train tares 122½ tons, of which 58 tons is from the power van and 17½ tons from the parcels vehicle. The gross weight with 52 first class and 47 second class passengers and 13½ tons of mail and baggage, approximates to 140 tons. Extensive use of aluminium was made in the construction of the trailers. The trains are air-conditioned and the power for this and other auxiliary services is supplied by two 34 b.h.p. National oil engines installed in each power car.

Eight-cylinder Harland & Wolff two-stroke engine as used by the New South Wales Government Railways. The 135-mm. by 220-mm. cylinders develop a maximum of 360 b.h.p. at 1,200 r.p.m., but normally the engine is set to give a top output of 330 b.h.p. at the same speed. The dry weight is equivalent to 14 lb. per b.h.p. on an output of 360 b.h.p.

THE KADENACY IMPROVEMENTS TO TWO-STROKES

A development which may lead to the much wider use of two-stroke engines for traction and other purposes

IN two-stroke engines cylinder scavenging is usually imperfectly performed because, when air is sent in under pressure to drive out the still turbulent products of combustion, a good deal of mixing takes place, and, by the time uni-directional flow has been set up towards the open exhaust port, the propelling air may be considerably vitiated. To ensure that on the closure of this port the cylinder contained nothing but uncontaminated air it would be necessary to pump in an inordinately large quantity for scavenging purposes, thus wasting power in driving a bulky blower. Actually it should not be necessary to spend any effort at all in expelling the burnt gases, for these possess enough energy to effect their own escape and to refill the cylinder with clean fresh air. Yet the general trend for years has been to try to force the exhaust out, and no notice has been taken of the return, or reaction, of exhaust gases leaving the cylinder with a high kinetic energy.

Self-Evacuation of Exhaust

In engines built according to the Kadenacy principles careful attention is given to the design of the exhaust passages and also to the timing of the port openings, so that the exhaust gases eject themselves precipitately, and the intake air follows immediately after them. By watching these points it has been found possible to secure a uni-directional flow of burnt gases towards the exhaust port almost immediately after release has taken place. A port admitting fresh atmospheric air can be opened by the time the exhaust pressure in the cylinder has fallen to about 5 lb. per sq. in., because by this time the outward flow of burnt gases has been so well established through the exhaust that there is no tendency either for gases to blow back through the air inlet or for incoming air to become mixed with such gases. If advantage is taken of the self-evacuating properties of the burnt gases, the boundary between air and gases remains well defined, and as the gases pass out air passes in by a process of natural aspiration, the exhaust and intake being two separate phases.

Excess Air

The energy with which the burnt gases escape is sufficient to draw through the inlet port before this closes about 1½ or more cylinder volumes of air. The excess air follows the exhaust gases out of the cylinder, and it produces a useful internal cooling effect, due to which an engine converted to work on Kadenacy principles can be run at higher power outputs and yet show no sign of overheated valves or pistons. This excess air with natural aspiration is a most striking feature, and not a little of the improved performance given by Kadenacy engines can be attributed to it.

Because a greater proportion of the waste heat passes down the exhaust pipe, a smaller proportion passes to the cooling jackets, and the diminution in some converted engines is striking. Higher power outputs are obtainable because the air in the cylinder is not contaminated with burnt gases, and will effect the efficient combustion of a larger charge of fuel than could be admitted to the cylinder of an ordinary two-stroke engine. This more sustained combustion gives a broader indicator diagram corresponding to a higher m.e.p., and yet the maximum or peak cylinder pressure may be lower than formerly. Not only are the cylinder temperature conditions easier, but less exacting conditions are experienced by the bearings.

Test Results

The Kadenacy type of engine further has shown itself to be more economical in fuel than pump-scavenged models. An idea of the extent of all these improvements was afforded by tests recently carried out on a single-cylinder 700 cc. Junkers opposed-piston engine before and after conversion. At the normal maximum speed of 1,200 r.p.m. the m.e.p. was increased from 84 to 130 lb. per sq. in., but the engine would run at the greater speed of 1,700 r.p.m. in conjunction with a m.e.p. of 136 lb. per sq. in., corresponding to 25 b.h.p. Compared with the original limit of 10·75 b.h.p. there was thus a 132 per cent. increase in the power output. The maximum cylinder pressure was reduced from 1,040 to 930 lb. per sq. in., when the m.e.p. was 90 lb. per sq. in., and was only 985 lb. per sq. in. for a m.e.p. of 140 lb. per sq. in. Actually the engine could be run up to 2,100 r.p.m. when converted in accordance with the Kadenacy principles. The fuel consumption in the original engine varied between 0·495 and 0·53 lb. per b.h.p.-hr. Over the same speed range with the converted engine it varied between 0·363 and 0·378 lb.

Patent Rights

The rights of the Kadenacy principles for all countries except France are held by the Armstrong Whitworth Securities Co. Ltd., of Slough, and although extensive experiments have been, and are being, conducted at the company's works, it is the policy to grant non-exclusive licences and not to manufacture engines. The Petter two-stroke Superscavenge engine is built with the application of Kadenacy principles, and operates with an m.e.p. of 82 lb. per sq. in., compared with 67 lb. previously. But on the test bench engines of this type have shown m.e.p.s of 100-125 lb. per sq. in. without giving any trouble or causing undesirable conditions. Experiments have been made also with an auxiliary marine engine, and Armstrong-Kadenacy engines have been designed and built to prove the extreme efficacy of the principle when unhampered by existing designs.

RAILCAR REPAIR EQUIPMENT.—To facilitate the repair of diesel railcar components the administration of the Entre Rios Railway has introduced into its workshops a number of simple and effective jigs, made partly from scrap material. One of the most interesting is a double-pedestal universal stand which accommodates either a Wilson gearbox, Vulcan-Sinclair fluid coupling, reverse gearbox unit, or an air-compressor assembly; the table and component can be rotated through 360 deg. and locked in any position. Trays for the tools are provided on the columns, and a removable tray is fitted in the lower part of the stand to collect the drained oil, dirt, and cleaning waste. Similar items at the Paraná workshops are a universal crankshaft stand; a stand and tray for fuel injection pumps and cam boxes, and a fixed air-compressor stand.

XUM

RAILCAR AIR RESISTANCE

A description of the calculations and test results obtained from a type of standard-gauge double-bogie car designed for speeds of 60 to 75 m.p.h., and having a smooth but not true aerodynamical contour

THE precise computation of the resistance of a railcar or of any railway vehicle on a purely theoretical basis is really impossible, but it is possible to give a rough estimate of the resistance on theoretical considerations with the addition of some practical figures gained by experience. The resistance of a railcar consists essentially of wheel and axle resistance and air resistance. In compliance with the results obtained from the resistance trials of ordinary rolling stock the running resistance may be assumed to be constant, and dependent on the car weight only. The resistance offered by the air has been found to vary approximately as the square of the velocity of the relative wind, and it is approximately true to say that the total resistance W is :

$$W = \alpha \,.\, G + \beta V^2 \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

where G is the weight of the car and V is the speed ; α and β are empirical figures.

Wind tunnel tests have shown that the air resistance W_A in kg., of a body can be expressed by the formula :

$$W_A = \frac{r}{2_g} V^2 (F_f \times C_f + F_s \times C_s) \ldots\ldots\ldots \quad (2)$$

where r denotes the specific gravity of air in kg. per m.^{3} ;

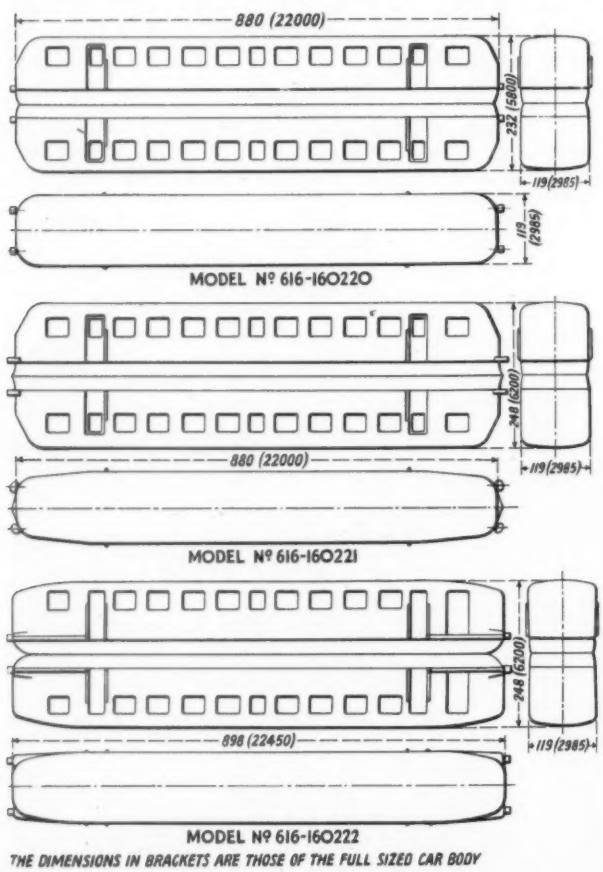


Fig. 1—Wind-tunnel model of Arpad railcar

g the gravitational acceleration in m. per sec.^{2} ; F_f the frontal area of the body in m.^{2} ; F_s the surface of the body along the direction of the wind in m.^{2} ; C_f coefficient of shape resistance ; and C_s the coefficient of frictional resistance ; V is the wind velocity in m. per sec. Tests have shown that C_f may be assumed at 0·3 to 0·5 for streamlined railcar bodies and C_s amounts to about 0·005 for smooth surfaces.

Values for shape resistance much lower than those quoted above are known in automobile and aeroplane practice, but owing to limitations in railway service the above mentioned figures cannot be appreciably reduced. A railcar generally must run in either direction, and both ends of the body must have practically the same shapes. The middle part of the body cannot possibly deviate from the usual prismatic shape, if suitable accommodation for the passengers is taken into consideration. Both these conditions render it impossible to give railcars an ideally streamlined body, and a certain compromise has to be made.

Air Resistance Coefficients

When designing the first Arpad express railcars, Ganz assumed the value of C_f to be about 0·50 and C_s to be 0·005, and a resistance of 2·2 kg. per ton was allowed for the friction of the wheels and axles. Allowance for the air resistance of the under part of the car was made by taking into consideration as frontal area the whole sectional area of the car from top of roof to rails. Thus, for a railcar of the Arpad type, having a body length of 22 m., a maximum width of 2·985 m., and a height above top of rails of 3·30 m., F_f was 9·85 m.^{2} and F_s equalled 277 m.^{2} including the surface of the underpart of the car. This gave the expression :

$$W = 2{\cdot}2G + \frac{1{\cdot}18}{2 \times 9{\cdot}81} (9{\cdot}85 \times 0{\cdot}50 + 277 \times 0{\cdot}005)\ V^2$$
$$= 2{\cdot}2G + 0{\cdot}38V^2.$$

If the speed be expressed in km.p.h. instead of m.p. sec. the above expression is reduced to :

$$W = 2{\cdot}2G + 0{\cdot}0292V^2.$$

In calculating this expression the specific gravity of the air was taken at 25° C. At temperatures other than this the specific gravity r of the air varies with the temperature in accordance with the well-known formula :

$$r = 1{\cdot}293 \times \frac{273}{273 + t^\circ} \quad \ldots\ldots\ldots\ldots \quad (3)$$

where t° denotes the air temperature in °C. Accordingly, at an ambient temperature of 30° C. the air resistance would be reduced by about 10 per cent. compared with the resistance at 0° C. The above formula was found to have given a fair approximation for the resistance of the Arpad railcars when coasting tests were carried out on the finished vehicles.

Two Test Methods

For the measurement of railcar resistance two methods are available, *viz.*, the coasting test, and the wind tunnel test. Coasting tests have the advantage that they require no special apparatus additional to that present in every railcar, and as the measurements are made on the car itself

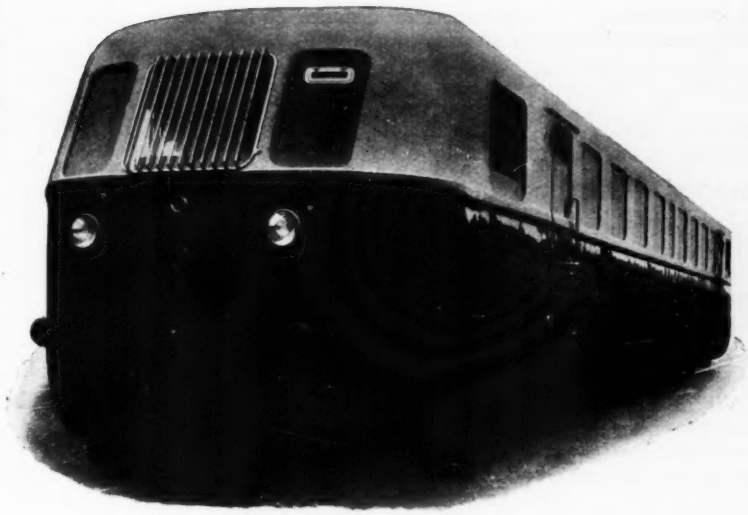


Fig. 1a—The double-bogie diesel-mechanical Arpad railcar of the Hungarian State Railways which for some years maintained a 56 m.p.h. business service between Budapest and Vienna. The aerodynamical design of this car, and others modelled on it, is discussed in this article

no assumptions have to be made to approach actual conditions. But this method has the drawback that it cannot be used for preliminary tests, and it is not possible to change the shape of the car in accordance with test results. Further, owing to irregularities of the track and weather conditions the figures obtained are subject to wide variations, and to obtain reliable average values a great number of tests have to be made, and this is expensive.

Wind Tunnel Possibilities

Wind tunnel tests are excellent for preliminary work and changes of shape of the model until the best results are attained enables a car of the most suitable contour to be built. If an existing wind tunnel is available, tests may be carried out at a comparatively low cost, but such investigations have the shortcoming that only the air resistance can be obtained, and even then certain assumptions have to be made. For instance, the way the model is made may greatly influence test results. If an ordinary wind tunnel is used, the model is often in the form of a double car (see Fig. 1), *i.e.*, two bodies turned with their underside against each other. Thus the effect of the air current passing below an actual car running on a track is neglected, and the whole test is carried out under "hot house" conditions.

Coasting Tests

In order to obtain a clear view of the resistance of a certain type of car it is advisable to collate the results obtained by both of the above-mentioned methods. Coasting tests should be carried out on a straight level track, with, if possible, no wind blowing, and it is advisable to make at least 6 to 8 runs alternately in either direction over the same track in order to eliminate some of the errors. Coasting should begin from the maximum speed attainable and continue as far as track conditions permit. This can be done by accelerating to top speed before arriving at the horizontal track section destined for the test runs. On entering the section the transmission is thrown into neutral and the engine is stopped. Thereafter the car will drift under its own inertia, and the speed will continually diminish as the kinetic energy is spent in the work performed against resistance.

Necessary Readings in Coasting Tests

In order to ascertain the resistance at different speeds, it is necessary to take frequent readings of the speed, time, and distance covered. This may be done either with the aid of a well-trained personnel allotting a separate person to each instrument, or by photographing the speedometer and stop watch placed side by side, by means of a small moving-picture camera making exposures at certain intervals. It is necessary to have a speedometer that indicates speed by a continuous movement of the pointer and not by jerk-wise sequence given by some types. Readings should be so taken that a table of speeds against distances covered is obtained, and another table of speeds against time. The exact weight of the car being known, either of these two tables supplies sufficient data for ascertaining the resistance.

In order to obtain the resistance, a distance-speed graph is first constructed from the record sheets. If the loss

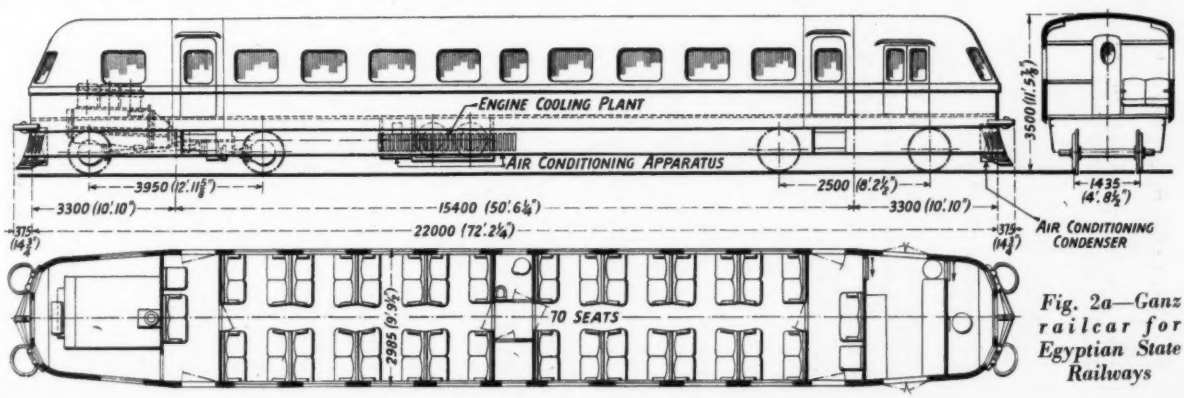


Fig. 2a—Ganz railcar for Egyptian State Railways

of kinetic energy during a certain distance equals the work performed against resistance, then :

$$\frac{(V_2^2 - V_1^2)\, m^1}{2} = S \times W_m \quad \ldots\ldots\ldots \quad (4)$$

where V_1 and V_2 respectively denote the car speeds in m.p.sec. on entering and leaving a certain section of the track ; $m^1 = \frac{G}{g}$, the mass of the car in $\frac{\text{kg. per sec.}^2}{m}$, including an allowance of 5 per cent. for the rotating masses ; S the distance in metres and W_m the mean of the resistance within the same track section. From this equation the resistance W_m may be expressed for each section, and thus a graph of the resistance as function of speed may be constructed.

Deceleration Curves

When constructing the curve of deceleration, efforts to trim the curve should not be carried too far. It would be very tempting, for example, to substitute the curve between about 100 and 30 km.p.h. by a straight line, but this would be wrong, as the curve of deceleration could be a straight line only if the resistance were also a linear function of speed, which, as is known from wind tunnel tests, is not the case.

Using the same symbols as above, it is known, that :

$$W ds = mv \times dv$$

and

$$\frac{dv}{ds} = - tg\ \delta$$

where δ is the angle of the tangent of the distance-speed curve. Wherefrom :

$$W = - mv \times tg\ \delta.$$

If the distance-speed curve were a straight line, then $tg\ \delta$ ought to be constant, meaning that

$$W = - m.v.\ const.$$

i.e., the resistance would vary in direct proportion with the speed.

In order to give a guide for the proper correction of the deceleration curve it is useful to re-construct a deceleration

TABLE I.—RESULTS OF COASTING TESTS, GANZ DOUBLE-BOGIE RAILCAR, EGYPTIAN STATE RAILWAYS. GROSS WEIGHT 37·48 TONNES ; ENGINE AT REAR ; 3 METRES PER SEC. WEST WIND ; SHADE TEMPERATURE 28° C.

Track section	Total dist.	Gradient ± 0/00	Time min. sec.	Speed km.p.h.	Track section	Total dist.	Gradient ± 0/00	Time min. sec.	Speed km.p.h.
	m.					m.			
1500		0	0	110	1552	5200	0	4 00	54
1503	300		0 10	107	53	5300		07	53
5	500		17	105	54	5400		14	52
7	700		23·5	103	55	5500		21·5	51
9	900		31	100	56	5600	0	29·5	50
1511	1100		37	99	57	5700	+ 1	36·5	50
13	1300		45	96	58	5800		44	49
15	1500		52·5	95	59	5900		52	48
17	1700		1 00	92	1560	6000		5 00	46
19	1900		08	90	61	6100		08·5	45
1521	2100		17	87	62	6200		17	44
23	2300		25	85	63	6300		26	42
25	2500		34	82·5	64	6400		35	41
27	2700		42	81	65	6500		45	39
29	2900		51·5	79	66	6600		55	38
1530	3000		56	77	1567	6700		6 06	36
31	3100		2 01	76	68	6800	+ 1	16	35
32	3200		06	75	69	6900	0	27	34
33	3300		11	74	70	7000		39	32
34	3400		16	73	1571	7100		51	31
35	3500		21	72	72	7200		7 04	30
36	3600		26	71	73	7300		17	29
37	3700		31	70	74	7400		31	27
38	3800		36	69	75	7500		45·5	26
39	3900		41	68	76	7600		8 01	25
1540	4000		46·5	67	77	7700		18	24
41	4100		52	66	78	7800		35	22
42	4200		58	65	79	7900		53	20
43	4300		3 03·5	64	1580	8000		9 15	19
44	4400		09·5	63	81	8100		37·5	17
45	4500		15	62	82	8200		10 04	15
46	4600		21	61	83	8300		33	13
47	4700		27·5	60	84	8400		11 12	10
49	4900		40	57	85	8500		12 18	5
1551	5100	0	52·5	55	85·7	8570	0	13 30	0

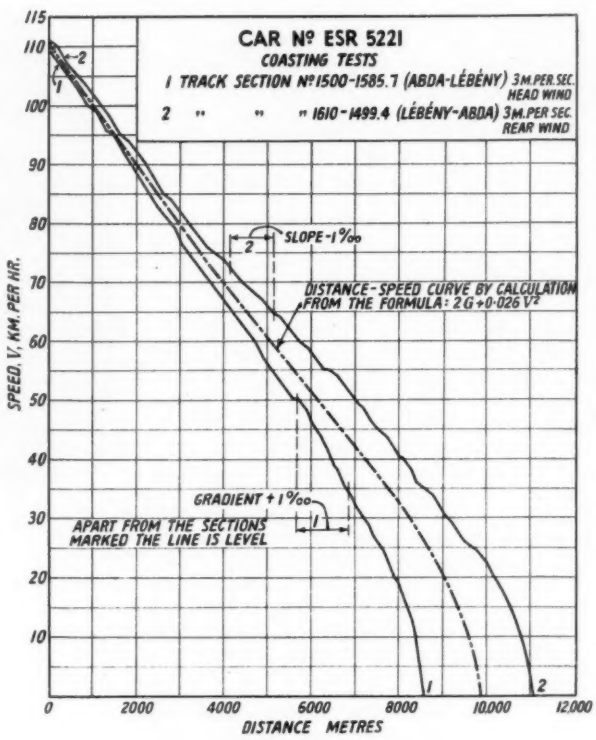
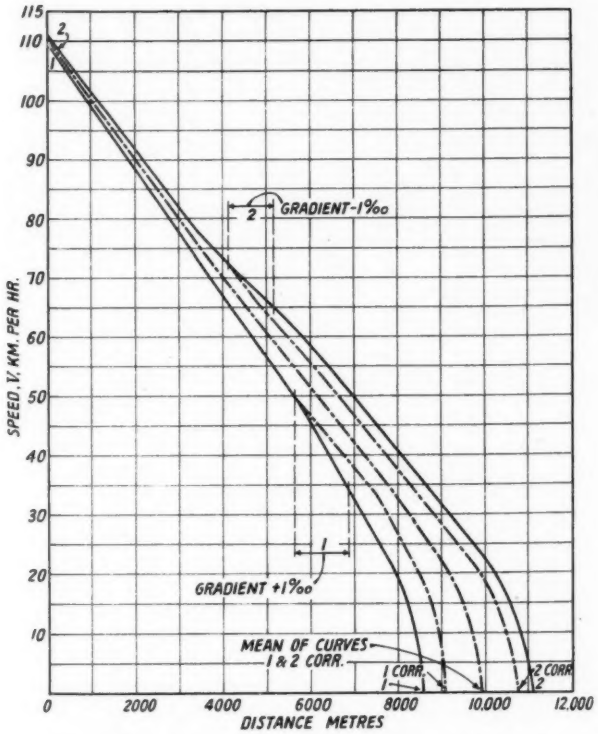


Fig. 2—Speed-distance curves obtained from coasting tests with car shown in Fig. 2a, with wind of 7 m.p.h. The tests were undertaken in Hungary

TABLE II.—RESULTS OF COASTING TESTS. GANZ DOUBLE-BOGIE RAILCAR, EGYPTIAN STATE RAILWAYS. GROSS WEIGHT 37·48 TONNES ; ENGINE AT FRONT ; 3 METRES PER SEC. WEST WIND ; SHADE TEMPERATURE 28° C.

Track section	Total dist.	Gradient ± 0/00	Time min. sec.	Speed km.p.h.	Track section	Total dist. m.	Gradient ± 0/00	Time min. sec.	Speed km.p.h.
	m.								
1610	0	0	0	111	42	6800	0	18	52
1608	200		0 6·5	110	41	6900		25	51
06	400		13	107	1540	7000		32	50
04	600		19	105	39	7100		39	49
02	800		26	104	38	7200		47	48·5
1600	1000		33	102	37	7300		55	47
1598	1200		40	100	1536	7400		6 03·5	46
96	1400		46·5	98	35	7500		10	45
94	1600		54·5	95	34	7600		18	44·5
92	1800		1 01·5	94	33	7700		27	44
1590	2000		09	92	32	7800		35	43
88	2200		17	90	31	7900		44	41·5
86	2400		25	87·5	1530	8000		53	40·5
84	2600		33	85	29	8100		7 02	40
82	2800		41·5	84	28	8200		12	39
1580	3000		50	82	27	8300		21	38
78	3200		58·5	80	26	8400		31	36
76	3400		2 07	78	25	8500		41	35·5
74	3600		17	76	24	8600		51	35
72	3800		26	75	23	8700		8 02	34·5
1570	4000		35	74	22	8800		13	34
69	4100	0	40	73	21	8900		24	32·5
68	4200	− 1	45·5	72	1520	9000		35·5	31
67	4300		50	71	19	9100		47	30
66	4400		55·5	70	18	9200		59·5	29·5
1564	4600	− 1	3 06	69	17	9300		9 12·5	28·5
63	4700		11	68	16	9400		26	27
62	4800		16·5	67·5	15	9500		39	26
61	4900		21·5	67	14	9600		53	25·5
1560	5000		28	66	13	9700		10 07	25
59	5100	− 1	32·5	65	12	9800		23	24·5
58	5200	0	38	64·5	1511	9900		10 38	23·5
57	5300		43·5	64	1510	10000		55	22·5
56	5400		49	63	9	10100		11 12	21
55	5500		55	62	8	10200		30	20
54	5600		4 01	61	7	10300		50	19
53	5700		07	60	6	10400		12 12	17·5
52	5800		12·5	59·5	5	10500		34	16
51	5900		18·5	59	4	10600		12 59	14·5
1547	6300		44	55	3	10700		13·28	12
46	6400		50·5	55	2	10800		14 04	10
45	6500		57	54·5	1	10900		54	7
44	6600		5 04·5	54	1500	11000		16 12	4
43	6700	0	11	53	1499·4	11060	0	17 30	0
									13h. 37



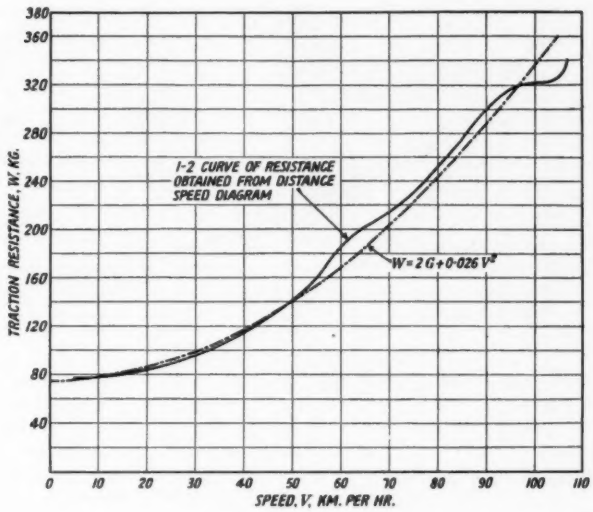


Fig. 4 (above).—Railcar tractive resistance curve obtained from distance-speed diagram drawn up from coasting tests with Ganz E.S.R. railcar

Fig. 3 (left)—Resultant curves of coasting tests directed to allow for short gradient shown in Fig. 2

curve from the definite resistance formula. Fig. 2 shows a curve thus re-constructed, and it will be seen that the middle part of the plot has a slight curvature and that there is an inflection at about 40 km.p.h.

The other means of obtaining the resistance from the results of coasting tests is the table of speeds and time. If speeds are plotted against time, the curve obtained will be similar in appearance to that from speed-distance. After having properly corrected this curve, the resistance may be obtained through the equation

$$W = m \times a \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

where a is the rate of deceleration in m.p.sec.^{2}. The value a may be obtained by dividing the curve into sections and deriving the mean of the deceleration within each section by means of the equation :

$$a = \frac{dv}{dt} \approx \frac{\Delta v}{\Delta t}$$

in which Δv denotes the drop of speed within one section and Δt the time spent during this deceleration.

Ascertaining the constant coasting speed over various down grades supplies a handy and fairly precise means of checking the results obtained by the above two means and may also prove useful for the definition of the resistance curve where level tracks of sufficient length are not available.

This test is based on the fact that if n is the slope in per cent. and G the weight of the car in tons, then the force Z in kg. acting on the car and tending to move it downhill will be

$$Z = 10 \times n \times G.$$

If a section the exact slope of which is known is entered at a speed at which it is estimated that the resistance would be about the same as the force Z, the car will very shortly attain the constant balancing speed at which the resistance is actually equal to the moving force of the slope, and thus supplies one point of the speed-resistance curve. For example, a coasting test (see Table VII) of a Ganz railcar, weighing 3,748 *tonnes* gave a balancing speed of 79 km.p.h. on a slope of 0·667 per cent., thus giving a resistance at this speed of $6{\cdot}67 \times 37{\cdot}48 = 250$ kg. (marked S in Fig. 8).

Tables I and II give actual test results of one of the Ganz railcars of the Egyptian State Railways. The results contained in these tables are represented in Figs. 2 and 5,

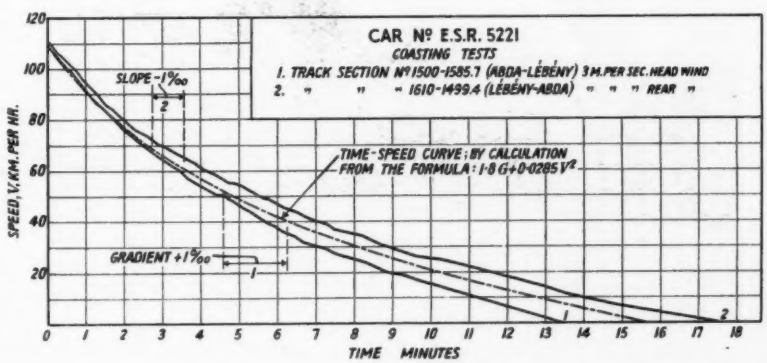

CAR Nº E.S.R. 5221
COASTING TESTS
1. TRACK SECTION Nº 1500-1585.7 (ABDA-LÉBÉNY) 3 M. PER SEC. HEAD WIND
2. " " " 1610-1499.4 (LÉBÉNY-ABDA) " " " REAR "
SLOPE -1‰
GRADIENT +1‰
TIME-SPEED CURVE: BY CALCULATION FROM THE FORMULA: 1·8 G+0·0285 V²
SPEED, V, KM. PER HR.
TIME MINUTES

Fig. 5—Time-speed curves obtained by calculation from coasting tests. The test results are compiled in tabular form on the opposite page, see Table II for Fig. 5, and Table I for Fig. 2

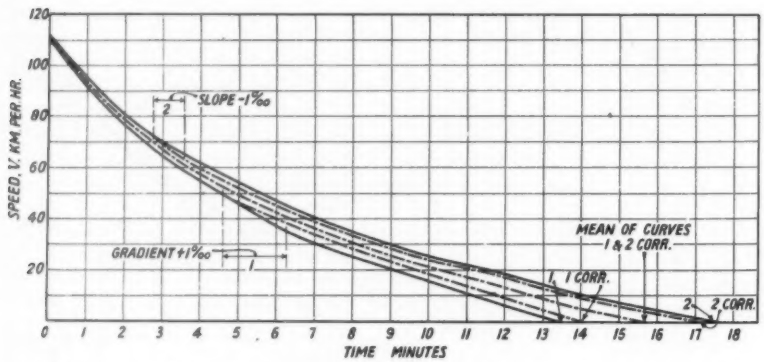


Fig. 6—Resultant time-speed curves corresponding to Table II and Fig. 5, corrected to allow for the short gradient

and Figs. 3 and 6 are diagrams of the same tests corrected to allow for some short gradients on the line and trimmed to enable the derivation of the curve of resistance to be made. Figs. 4 and 7 are the diagrams of tractive resistance against speed obtained by means of the formulæ (4) and (5) from Figs. 3 and 6. In the same diagrams are also shown the curves of the formulæ, giving a fair approximation of the test diagram. Fig. 8 shows the two curves, one obtained by the traction resistance formulæ from the time-speed, and the other from the distance-speed diagram. Fig. 8 also gives the resultant curve of the two tests, which may be taken as the mean of the above two ways of measurement and calculation. For the sake of simplicity two tests

TABLE III.—LEADING PARTICULARS OF SINGLE-UNIT GANZ CARS ON THE EGYPTIAN STATE RAILWAYS

One 240 b.h.p. engine mounted on bogie at one end	
Wheel dia.	0·92 m. (36 in.)
Bogie wheelbase	3·95 m. (13 ft.) driving
	2·50 m. (8 ft. 2½ in.) trailing
Pitch of bogies	m.
Overall length of body	22 m. (72 ft. 2½ in.)
Max. width of body	2·985 m. (9 ft. 9¼ in.)
Height above rails	3·5 m. (11 ft. 6 in.)
Max. service speed	110 km.p.h. (68 m.p.h.)
Weight empty, but including supplies	37·5 *tonnes*
Seating capacity	70

Described in issue of this Supplement dated September 6, 1935.

only are shown as examples, these two being representative of a number of tests and giving about average values. It will be noted that the resulting formula for traction resistance is slightly more favourable than that obtained for the Arpad type of railcar, in spite of a somewhat higher wind resistance of the body as shown by the wind-tunnel tests discussed later. This may be attributed partly to the higher temperature—28° C.—at which the tests were performed, and partly to a slightly lower resistance of the underside of the car body, which, in this case being occupied to a greater extent by auxiliary machinery and air-conditioning plant, may have given a closer approximation of a solid body or of a covered underside, thus offering less opportunity for the formation of a turbulent air flow below the car body. A certain allowance must naturally be made for errors of measurement. To be on the safe side it seems advisable to use a formula giving somewhat higher resistance figures, and therefore the use of the original formula (for 25° C.) of: $W = 2{\cdot}2G + 0{\cdot}029V^2$ may in this case also be justified. It is advisable to make allowance for eventual lower ambient air temperatures.

Wind-Tunnel Tests

If existing tunnels made for testing aeroplane models are used, the railcar models must be suitably adapted. The most usual way of testing is to make a double model, *i.e.*, the model of the body of the railcar will be made in duplicate and these two assembled bottom against bottom, giving a model symmetrical to the dividing plane and thus permitting an air flow similar in character to that caused by a railcar running close to the ground. In addition to wheel and axle friction the resistance caused by the air current passing below the car is neglected, and it will have to be estimated separately by comparing wind-tunnel tests with the results of drifting tests.

Exhaustive tests were carried out on the models of three different types of Ganz railcar bodies at the wind tunnels of the Vickers Aviation Co. Ltd., at Weybridge (see Fig. 1). In addition to testing the models in an air flow parallel to the longitudinal centre lines, measurements were made with the models turned at different angles to the flow in order to investigate the influence of resultant wind.

The results of these tests are shown in Tables IV to VI

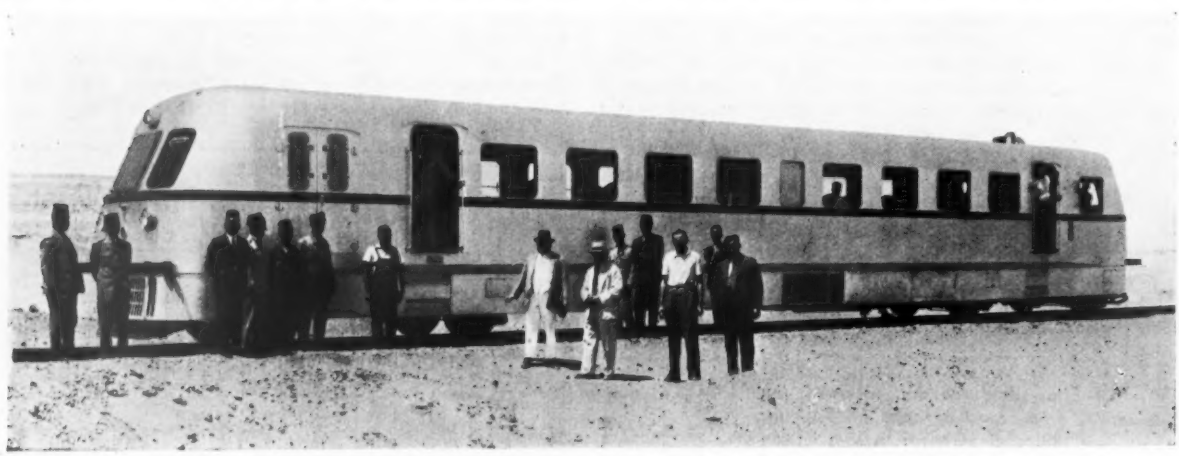


Fig 6a.—A test run on the Suez line with one of the 240 b.h.p. Ganz cars of the Egyptian State Railways

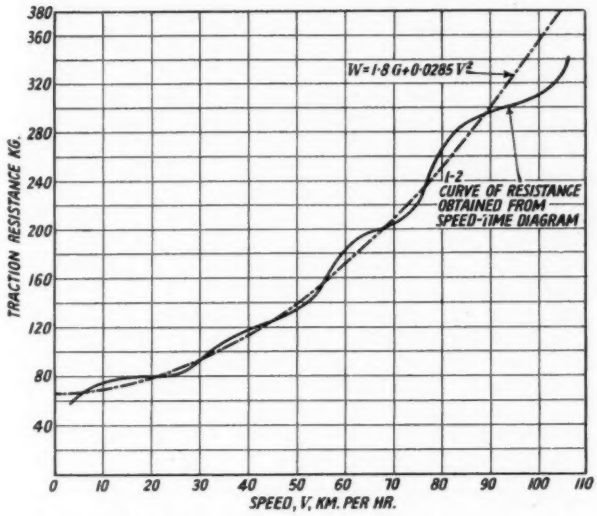


Fig. 7—Tractive resistance curve obtained by means of equation (5) from Fig. 6

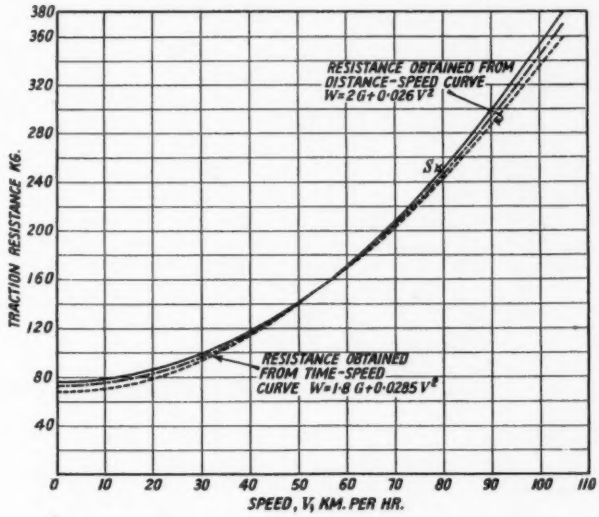

RESISTANCE OBTAINED FROM DISTANCE-SPEED CURVE W=2 G+0·026 V²
RESISTANCE OBTAINED FROM TIME-SPEED CURVE W=1·8 G+0·0285 V²
TRACTION RESISTANCE KG.
SPEED, V, KM. PER HR.

Fig. 8—Comparison of curves obtained from time-speed and distance-speed diagrams

for models set at angles of 0 deg., 15 deg., 30 deg., and 40 deg. to the direction of the air-flow. The figures given already refer to full-scale bodies. In the tables, V_A denotes the component of wind velocity parallel to the longitudinal centre line and V_R the component acting perpendicularly to it; A and R are the components of the force acting in the directions of V_A and V_R respectively. It will be seen that the components acting in the direction of the longitudinal centre line sometimes diminish at the larger angles of resultant wind, which is explained by the fact that the components $P_A \cos \vartheta$ and $P_R \sin \vartheta$ of the wind pressure P_A and P_R (see Fig. 9) act against each other, and although P_A and P_R may be large in themselves, their difference may be comparatively little. Consequently the accuracy of the figures at such angles is very low. An exact knowledge of resistance figures at these great angles is not of major importance, because it would take an almost disastrous gale to make up a resultant wind of such angle at higher car speeds, and naturally high track speeds are never stipulated for such weather conditions. The components $P_A \sin \vartheta$ and $P_R \cos \vartheta$ acting vertically to the longitudinal centre line are additive, and, as may be seen from the test results, very high side forces result.

In order to give an idea of the variation of the resistance figures as a function of the direction of the resultant wind, the coefficients β_A and β_R are shown in Tables IV to VI, where

$$\beta_A = \frac{A}{V_A^2} \text{ and } \beta = \frac{R}{V_R^2}.$$

Fig. 10 shows the coefficients β_A for defining the forces acting in the direction of the longitudinal centre line, plotted against the ratio $\frac{V_R}{V_A}$, and shows the wind resistance in a beam wind of 0 to 60 per cent. of the car speed. Of course, if the direction of the wind is not exactly perpendicular to the direction of running, the speed and angle of the relative wind may be obtained easily by adding the vectors of car speed and wind, and on basis of the two

TABLE IV.—AIR RESISTANCE COEFFICIENTS FROM TRACK TESTS, GANZ ARPAD DOUBLE-BOGIE RAILCAR WITH SHELL-TYPE BUFFERS

0° Angle between centre line of railcar and directions of air flow—					
V_A =	75	100	120	150	km.p.h.
A =	122	217	312	490	kg.
From these : β_A = 0·0217					
V_R = 0 km.p.h.					
R = 0 kg.					
15° Angle between centre line of model and direction of air flow—					
V_A =	116	120	145	150	km.p.h.
A =	332	355	521	555	kg.
From these : β_A = 0·0247					
V_R =	31	32·2	38·9	40·2	km.p.h.
R =	1540	1650	2410	2580	kg.
From these : β_R = 1·592					
30° Angle between centre line of model and direction of air flow—					
V_A =	104	120	130	150	km.p.h.
A =	289	385	452	602	kg.
From these : β_A = 0·0267					
V_R =	60	69·3	75	86·6	km.p.h.
R =	3490	4670	5490	7300	kg.
From these : β_R = 0·973					
40° Angle between centre line of model and direction of air flow—					
V_A =	92	115	120	150	km.p.h.
A =	16	25	27·2	42·7	kg.
From these : β_A = 0·00189					
V_R =	77	96·6	101	126	km.p.h.
R =	5260	8260	9000	14,050	kg.
From these : β_R = 0·883					

TABLE V.—AIR RESISTANCE COEFFICIENTS FROM WIND-TUNNEL TESTS OF MODEL OF GANZ DOUBLE-BOGIE RAILCAR FOR THE E.S.R.; SEMI-ELLIPTIC BUFFERS

0° Angle between centre-line of model and direction of air flow—					
V_A =	75	100	120	150	km.p.h.
A =	133·5	235	339	522	kg.
From these : β_A = 0·0235					
V_R = 0 km.p.h.					
R = 0 kg.					
15° Angle between centre line of model and direction of air flow—					
V_R =	116	120	145	150	km.p.h.
A =	393	421	616	662	kg.
From these : β_A = 0·0293					
V_R =	31	32·2	38·9	40·2	km.p.h.
R =	1630	1750	2545	2730	kg.
From these : β_R = 1·69					
30° Angle between centre line of model and direction of air flow—					
V_A =	104	120	130	150	km.p.h.
A =	250	334	391	521	kg.
From these : β_A = 0·0231					
V_R =	60	69·3	75	86·6	km.p.h.
R =	4020	5350	6290	8400	kg.
From these : β_R = 1·12					
40° Angle between centre line of model and direction of air flow—					
V_R =	92	115	120	150	km.p.h.
A =	182·5	286	311	485	kg.
From these : β_A = 0·0216					
V_R =	77	96·6	101	126	km.p.h.
R =	5710	8920	9750	15,200	kg.
From these : β_R = 0·958					

XUM

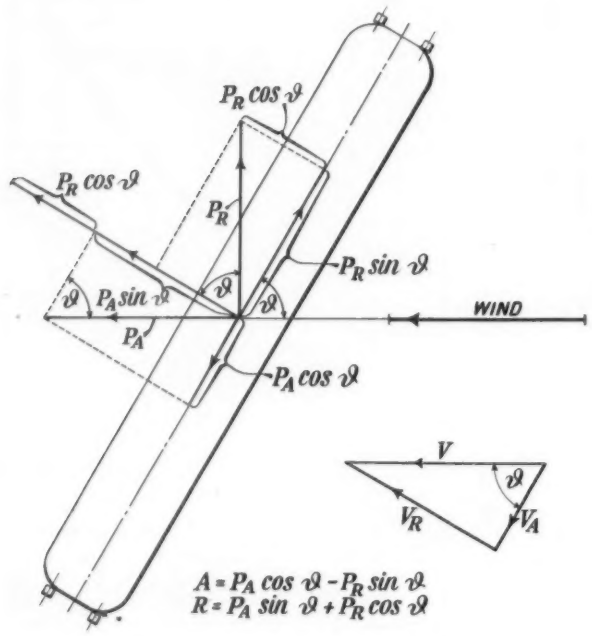


Fig. 9—Wind forces acting on railcar (see also Tables IV to VI)

vertical components of this resulting wind velocity the required resistance figure may be read off the diagram.

The resistance offered by the underside of the car is not considered in the figures given previously, and an attempt to ascertain it may be made by comparing the results of the wind-tunnel tests with those obtained in actual coasting tests. It was found through drifting tests that the resistance of the Arpad type of railcar complied approximately to the formula (at 25° C.) :

$$W = 2 \cdot 2G + 0 \cdot 029V^2.$$

Wind-tunnel tests gave for this shape of car body the value $V = 0 \cdot 0217$ for $\vartheta = 0°$; the difference between the two values of the coefficient of V may be attributed to the resistance offered by the wind beneath the car body and may be taken thus :

$$\beta u = 0 \cdot 029 - 0 \cdot 0217 = 0 \cdot 0073.$$

Converting this figure to the same form as the values in formula (2), a value of $C_s = 0 \cdot 024$ results, which is almost five times as great as the air resistance along a smooth polished surface. This increase may be attributed to the numerous excrescences below the car, to the turbulence of the air in the enclosed space between car body and truck ; by partly or wholly covering these, the value may be somewhat, though not much, reduced. But it must be borne in mind that this must be done in a way such that accessibility of the mechanical equipment is not made more difficult. Often the total enclosure of the underside of the car body with all its fittings would cause more inconvenience in maintenance than would be justified by the probable gain through a slightly reduced resistance.

Working from the value $\beta_A = 0 \cdot 0217$, the coefficient C_F of formula (2) will be :

$$C_F = 0 \cdot 43.$$

In this calculation, differently from the method adopted when making the first approximation, the value C_F is referred only to the part of body above the centre line of the axles, with a cross section of 8·65 m.² and the surface of the bottom of the car is likewise not included in the total side surface area of 193 m.², because in the factor 0·0073 this had already been considered.

In coasting tests such as outlined above, the resistance includes that offered by certain parts of the transmission,

TABLE VI.—AIR RESISTANCE COEFFICIENTS FROM WIND-TUNNEL TESTS OF MODEL OF PROPOSED NEW FORM OF GANZ RAILCAR TO GIVE LESS AIR RESISTANCE ; SHELL-TYPE BUFFERS

0° Angle between centre line of model and direction of air flow—

V_A =	75	100	120	150	km.p.h.
A =	110	195	281	438	kg.

From these : $\beta_A = 0 \cdot 0195$

$V_R = 0$ km.p.h.
R = 0 kg.

15° Angle between centre line of model and direction of air flow—

V_A =	116	120	145	150	km.p.h.
A =	289	309	452	485	kg.

From these : $\beta_A = 0 \cdot 0215$

V_R =	31	32·2	38·9	40·2	km.p.h.
R =	1520	1628	2365	2535	kg.

From these : $\beta_R = 1 \cdot 57$

30° Angle between centre line of model and direction of air flow—

V_A =	104	120	130	150	km.p.h.
A =	153	204	239	319	kg.

From these : $\beta_A = 0 \cdot 0142$

V_R =	60	69·3	75	86·6	km.p.h.
R =	3850	5120	5980	7970	kg.

From these $\beta_R = 1 \cdot 06$

40° Angle between centre line of model and direction of air flow—

V_A =	92	115	120	150	km.p.h.
A =	124·5	195	213	332	kg.

From these : $\beta_A = 0 \cdot 0148$

V_R =	77	96·6	101	126	km.p.h.
R =	5790	8980	9880	15,300	kg.

From these : $\beta_R = 0 \cdot 964$

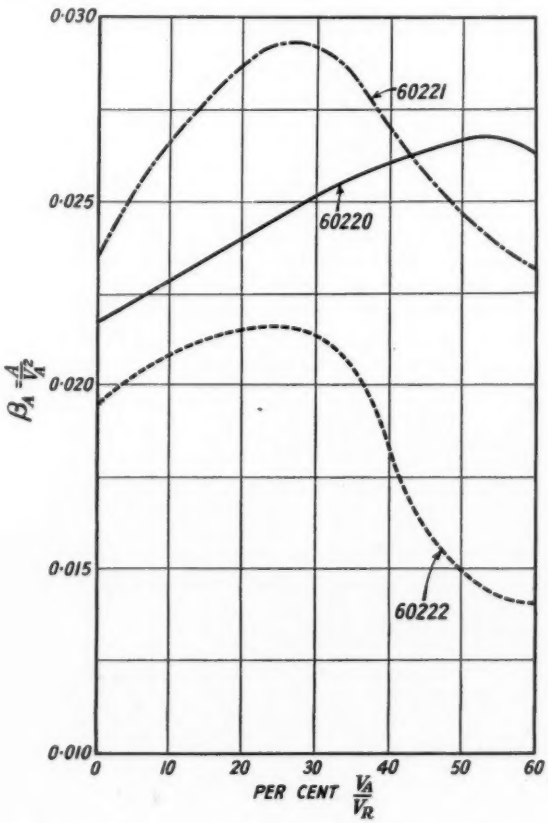


Fig. 10—Values of coefficients for defining the forces acting on the car in the direction of the longitudinal centre line

which are in movement when the engine is at standstill, *e.g.*, final drive and cardan shafts. When calculating the speed attainable, these losses are also included in the efficiency of the transmission, and actually they should not be taken into account a second time in the traction resistance. Nevertheless, in foregoing calculations these losses are included twice, in order to give a certain margin for eventual errors in measurement and calculations.

An examination of the data in this article will indicate that for speeds of 100-120 km.p.h. (62-75 m.p.h.), the air resistance, although important, does not justify extremes in respect of aerodynamical form, as the power savings would be comparatively small, and for such speeds it is never reasonable to insist on a slightly more suitable aerodynamic shape at the expense of other practical railway operating requirements.

TABLE VII.—BALANCING SPEED TESTS, GANZ CAR FOR EGYPTIAN STATE RAILWAYS; GROSS WEIGHT 37·48 *Tonnes*; SHADE TEMPERATURE 28° C.

Track section	Time of reading hr. min.	Speed achieved km.p.h.	Gradient over which max. speed achieved ± 0/00	Gear setting	Engine at front or rear	Remarks
550–600	10 55	(enter) 82 (end) 86	+ 6·66	V	rear	Full fuel.
620–720	11 0	(enter) 78 (end) 79·5	− 6·67	—	,,	Coasting.

Recent Small Diesel Locomotives

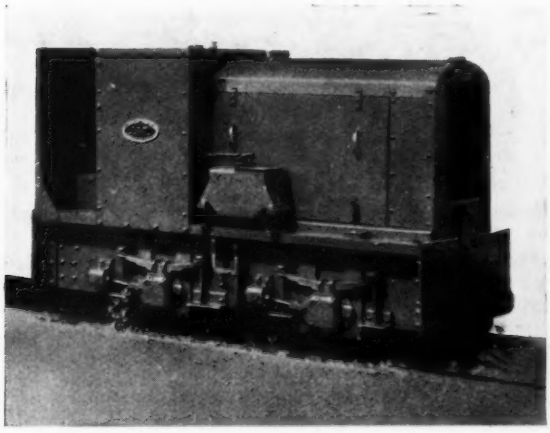
ONE of the features of British constructional practice for small diesel locomotives within the last year or so has been the number of units built with flameproof equipment. One of these, for the oilfields of the Anglo-Iranian Oil Company, was built some little time ago by F. C. Hibberd & Co. Ltd. It is equipped with a National diesel engine set to give 36 b.h.p. at 1,000 r.p.m. A three-speed gearbox is fitted and at top engine revs. gives track speeds of 3·3, 5·5, and 8·9 m.p.h., the corresponding tractive efforts being 3,000, 1,980, and 1,240 lb. All the gears are operated by a single hand-wheel control which gives simple and easy change merely by turning the wheel. The reversing gear is operated by a separate lever. A flexible coupling is fitted between the engine and gearbox, and as it is of a rubber fabric type all the shocks are well cushioned before they reach the engine. With this type of gearbox the clutch control is eliminated. The final drive from the gearbox to the axle is by means of chains.

Sanding gear of a special type with a single lever control provides sand for the leading wheels in either direction. The driver is seated across the cab, so as to give vision in either direction. The four wheels are spread over a base of 5 ft. 6 in., and the locomotive can negotiate curves of 45 ft. radius. The axleboxes are outside the frame and are fitted with roller bearings. Central buffing and draw gear is fitted at each end of the channel frame structure.

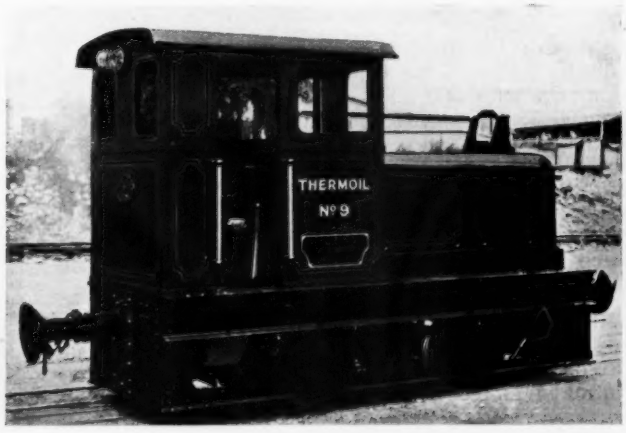
The National oil engine is of the four-cylinder type and incorporates the maker's patent combustion chamber, which has the feature of horizontal valves. These valves may be withdrawn from the cylinder heads without disturbing any joints or breaking any pipe connections. Great care has been taken to protect the engine from dust and a large Vokes filter is provided on the engine air intake. To ensure that all air taken into the cylinders passes through this filter, grooves are machined on the under side of the valve covers, into which felt is inserted. The engine crankshaft is extended to take a pulley for driving a radiator fan. The temperature of the atmosphere on site reaches 125° F. in the shade and therefore a very large radiator has been fitted to the front of the bonnet. Hibberd patent spark-arresting apparatus is included in the equipment and is arranged to ensure the minimum evaporation of water. The electric lighting equipment is also flameproof in accordance with the regulations of the Department of Mines.

Loco-Tractors

Recent Drewry deliveries include several 4- to 5-ton diesel-mechanical locomotives powered by Lister, Perkins, and Ailsa Craig engines, and for use on narrow-gauge tracks. The unit illustrated on this page is equipped with a 25 b.h.p. Ailsa Craig four-stroke engine. The transmission comprises a 14-in. Borg & Beck clutch and a three-speed gearbox giving track speeds of 3, 5, and 9 m.p.h. in either direction at top engine revs. The final drive to the axles is through 1½-in. pitch Renold roller chains. The 18-in. wheels are spread over a base of 3 ft., and sand is applied to them by gravity.



5-ton Drewry loco-tractor for operation on lightly-laid 2-ft. gauge tracks



Hibberd diesel locomotive for operation under tropical and bad dust conditions

Notes and News

Portuguese Diesel Prospects.—The Portuguese Railways have been enquiring for a dozen diesel locomotives in powers from 150 to 300 b.h.p., to run on 5 ft. 6 in. tracks. The type of transmission is left to the tenderer.

Producer-Gas Locomotives.—A number of small producer-gas locomotives with the Svedlund type of plant are being set to work, principally in short-distance freight service, on small Swedish railways, and several light petrol railcars and rail buses have been converted to producer-gas propulsion. Wood is the fuel used.

North-Western (India) Railcars.—In the first 77 days of their mass operation in passenger traffic on the Jullundur, Amritsar, and Ferozepore areas, the 11 Ganz railcars of the North Western Railway of India covered 210,280 miles. The cars are pool-operated by Indian steam locomotive drivers, of whom 36 have already been trained and certified.

Diesel Lubricating Oils.—According to a paper on fuel and lubricating oils read before the Société des Ingénieurs Civils de France by M. Jacques André, the high-speed four-stroke in general requires a lubricating oil with a paraffin base (Pennsylvania type). For two-stroke engines, in which the exhaust valve and gear and the piston rings are vital details, a lubricating oil with a naphtha base (U.S.S.R., Texas, &c.) was recommended.

New Combustion Chambers.—An improved form of combustion space for precombustion chamber oil engines has been patented by Dr. A. J. Büchi, and comprises pockets formed in the piston crown, one under each valve, which slope up to a small pocket below the antechamber. Petters Limited also has patented a new combustion chamber; it has a cylindrical recess in the piston crown from which a tangential groove leads to the injection nozzle.

Central Argentine Railcars.—According to Mr. D. M. Macrae, General Manager, the Ganz diesel railcar services inaugurated in April, 1938, by the Central Argentine Railway between Buenos Aires and Capilla del Señor, and in the following July between Buenos Aires and Zarate, have proved very successful from the standpoints of economy in operation and increased passenger traffic. These services have now been extended to Pergamino and San Pedro. The monthly mileage is now about 88,000, and the average speed is approximately 40 m.p.h.

Shunting Locomotive Mileage.—From being put into traffic in 1933 until the end of 1938 the Bo-1-Bo shunting locomotive with 600 b.h.p. Sulzer engine of the French National Railways (ex-P.L.M. division) covered 132,000 km. (82,000 miles) and operated 29,076 hours, or approximately 5,350 hr. a year. Later diesel-electric locomotives with Sulzer engines giving 635 b.h.p. at 735 r.p.m. were put to work in the Région du Sud-Est on October 18, 1938, November 30, 1938, and February 6, 1939, and up to March 31, 1939, had covered respectively 9,817 km. (2,082 hr.), 10,339 km. (2,251 hr.), and 3,870 km. (957 hr.).

American News.—The Boston & Maine Railroad has ordered three 600 b.h.p. Electro-Motive and one 600 b.h.p. Alco diesel-electric switching locomotives. The New York Central has ordered five 600 b.h.p. Electro-Motive switchers. The Rocky Mountain Rocket diesel-hauled train of the Chicago, Rock Island & Pacific began operation on November 12 between Chicago, Denver and Colorado Springs on schedules of 19 hr. eastbound and 19½ hr. westbound for the 1,084 miles. On November 5 the Zephyr trains on the Chicago, Burlington & Quincy topped 8,000,000 service miles since the Pioneer Zephyr began regular service in 1934. The new diesel-hauled 400 trains running between Chicago and the Twin Cities handled 12,186 passengers in and out of Chicago during the first month of service; for the same period a year ago the steam-hauled 400 handled 8,047 passengers. Each of the two new 400 trains is hauled by a twin-unit 4,000 b.h.p. diesel-electric locomotive, and the train is a ten-car set; the locomotive weighs 276 long tons and the coaches 515 long tons. The Erie Railroad has ordered three 1,000 b.h.p. Electro-Motive and four 600 b.h.p. Alco diesel-electric switching locomotives, and the Newburgh & South Shore Railroad one 1,000 b.h.p. Alco locomotive. Beginning on December 1, the diesel-hauled Silver Meteor between New York and Florida has operated as a daily service.

Sudan Locomotive Performance.—The two 350 b.h.p. six-wheel diesel-electric shunting locomotives built by the English Electric Co. Ltd. (mechanical portion by R. & W. Hawthorn, Leslie & Co. Ltd.) for the Sudan Railways, have been working satisfactorily at Port Sudan for about two years. They are employed in heavy continuous shunting, working 5,000 hr. a year, and are popular with the traffic staff.

Trade Publications

Radiators.—A four-page brochure (List No. 55) is to hand from the Spiral Tube & Components Co. Ltd., Derby, giving particulars of Spiral Tube radiators for diesel engine lubricating oil, and illustrating in section the newest form of cooling element for this purpose.

Pressure-Charged Engines.—As we announced in the November 24 issue of this Supplement, Ruston & Hornsby Limited, of Lincoln, has introduced a range of vertical engines for which Büchi pressure-chargers are considered as standard equipment. A simple exposition of the principles and practice of pressure-charging is given in one of Ruston's latest brochures, entitled *Extra Power from Extra Air*.

National Bulletin.—The November issue of this monthly publication of the National Gas & Oil Engine Co. Ltd., of Ashton-under-Lyne, contains brief particulars of one of the National alternative-fuel engines of 220 b.h.p., and a longer account of a sewage disposal plant equipped with the firm's slow-speed oil engines. The December issue contains descriptions of a gold-mining plant, a cinema plant, and portable generating equipment, all with National engines.

Horizontal Engines.—Not all of the Blackstone-Brush horizontal oil engines are suitable for rail traction applications, because of their bulk, and, as far as railcars are concerned, by the weight, too. But three of the four-cylinder engines, giving 190, 280, and 355 b.h.p. respectively, appear to be suitable for shunting locomotives, although the low speed 330-430 r.p.m. would give a heavy transmission. Nevertheless, a horizontal engine for yard locomotives has many attractions, and a study of the Blackstone-Brush catalogue No. 905B will yield some interesting information about a well thought out engine design and its possibilities in railway work. This publication is issued from the Stamford works of Blackstone & Co. Ltd.

Electric Railway Traction

The Swiss 12,000-h.p. Locomotive

A CONSIDERABLE advance in the design and construction of single-phase traction equipment appears to have been made in the new Oerlikon locomotive for the Gotthard route of the Swiss Federal Railways. Compared with the 8,625 h.p. (one-hour) locomotive of similar make set to work in 1932, the output on the same rating has been raised by 38 per cent. although the gross weight of the electrical equipment has been reduced by 4 per cent. The ratings adopted have been governed by the specifications of the International Electro-Technical Commission, whereas the previous locomotive incorporated electrical equipment built to the Swiss Federal Railways' own requirements, and this change has permitted much of the increase in power. In accordance with these ratings the armature and field windings are permitted a temperature rise (measured by resistance) of 105° C. on the continuous rating and 120° C. on the one-hour rating (Specification I), and 105° C. on both continuous and one-hour-ratings according to the I.E.C. rating No. II; these are for Class B insulation. As indicated in the table on page 88, two one-hour ratings have been given to the traction motors of the new locomotive, one based upon current and the other upon voltage. The gross output at the motor-shafts in accordance with I.E.C. rating No. 1 is 8,900 kW at 44·5 m.p.h., and in accordance with I.E.C. rating No. 2 is 8,400 kW at 46·5 m.p.h.

Electric Traction on the Italian State Railways

ELECTRIFICATION of the Italian State Railways began in 1901 with the first conversion on the Milan—Porto Ceresio line, and for main lines in 1902 when three-phase trials were begun on the Valtellina route. The route mileage electrified had risen to 300 in 1918, 435 in 1922, 1,215 in 1932, 1,475 in 1934, and 2,460 at the end of 1938, and the current consumption rose from 457 million kWh in 1934-35 to 750 million kWh in 1936-37, and to 873 million kWh in 1937-38. Owing to the rapid expansion of electric traction within recent years the building of State-owned power stations mainly for railway service has not kept pace with the demand for traction current, and about 73 per cent. of the energy consumed in the fiscal year 1936-37 was obtained from privately-owned generating companies with an installed capacity of 275,000 kW in hydro-electric stations and 34,350 kW in steam stations. The proportion of purchased current is falling as new State-owned plants are opened, and in 1937-38 the proportions were almost 50-50. Energy is supplied to the electrified railways through a total of 4,200 miles of transmission lines at 66 to 130 kV, most of which was constructed by the electrical engineering staff of the State Railways. A special control service, working with a comprehensive telephone system, is used to ensure the most economical and reliable distribution from the various supply networks. In addition to being of value in emergencies, the intelligent use of this control has enabled the price of current to be reduced, and further has helped to reduce the current consumption from 32·5 watt-hr. per tonne-km. as recorded over the years 1931 to 1935, to 29·4 watt-hr. per tonne-km. in 1936-37. In this last-named fiscal year the cost of current was 0·142 lire per kWh, equivalent to 0·0042 lire per tonne-km. Over the same period the cost of coal per tonne-km. with steam traction was 0·0056 lire per tonne-km. with coal at 110 lire per *tonne*, giving a saving of 0·0014 lire per tonne-km. (or 25 per cent.) in favour of electric traction. But in 1938 the price of coal rose to more than 150 lire per *tonne*, and the saving has risen to 0·0034 lire per tonne-km. in favour of electric traction. The average initial cost of a 3,000-volt d.c. electric locomotive is 17 lire per kg. of weight, as against 11 lire per kg. for steam locomotives, but the weight per h.p. is only 34 kg. compared with 75 kg. By their higher speed with given trains and traffic, electric locomotives have improved the general efficiencies of the lines over which they operate, and in 1936-37 the 1,190 electric locomotives ran 52 million train-km., whereas the 3,200 steam locomotives ran only 87 million train-km., averages of 44,000 and 27,000 train-km. a year respectively. The cost of locomotive repairs also is in favour of electric traction, the repair charges being 0·93 lire per train-km. for electric locomotives and 1·52 lire per train-km. for steam locomotives. Moreover, by the elimination of smoke and ash, the maintenance and repair of the rolling stock is less on the electrified sections. Again, during the period 1936-37 electric traction required 66 train-crew staff and 13 repair shop workers per million train-km., contrasted with 99 and 65 respectively with steam haulage. In the same year the electrified lines represented 25 per cent. of the total route length of the Italian State Railways, but they carried 25,000 million tonne-km. out of a total of 57,000 million tonne-km. for the whole system. Coal consumption on non-electrified lines in that year was 1,800,000 *tonnes* in traffic and 200,000 *tonnes* in shunting, but if there had been no electrified lines the importation of coal would have risen by about 1,300,000 *tonnes*. Electric traction on the lines converted since the beginning of 1939 and on the lines now in process of conversion, will enable a further saving of 350,000 *tonnes* of coal a year to be made, and when the conversion of the 9,000 km. (5,600 miles) of route sanctioned in 1932 is complete, the total yearly coal saving will be of the order of 2,500,000 *tonnes*. The operation of the remaining 8,000 km. (5,000 miles) of route which are not scheduled for electrification will require the consumption of only 600,000 *tonnes* a year, and even this figure can be reduced by the increased use of railcars which is contemplated. For the electrification of approximately 1,100 km. (685 miles) of route scheduled to be opened this year, and including the lines turned over to electric traction since the beginning of January, an expenditure of about 600 million lire has been necessary, and of this sum about 81¼ million lire have been spent abroad; that is, out of a cost of about 545,000 lire per route-km., 73,800 lire purchased foreign equipment or materials. On these schemes in progress, a saving of 8·6 million lire has been made by using Italian-produced aluminium for the e.h.t. transmission lines in preference to the imported copper used for previous conversions.

Electric Motive Power Progress in Switzerland

ALTHOUGH there are no conversion schemes of any magnitude under way in Switzerland just now, except the electrification on the 15-kV 16⅔-cycle single-phase system of the Sud-Ost Bahn, over a route length of about 32 miles, there is considerable activity one way or another on the electrified sections of the Swiss Federal Railways and on the electrified private lines.

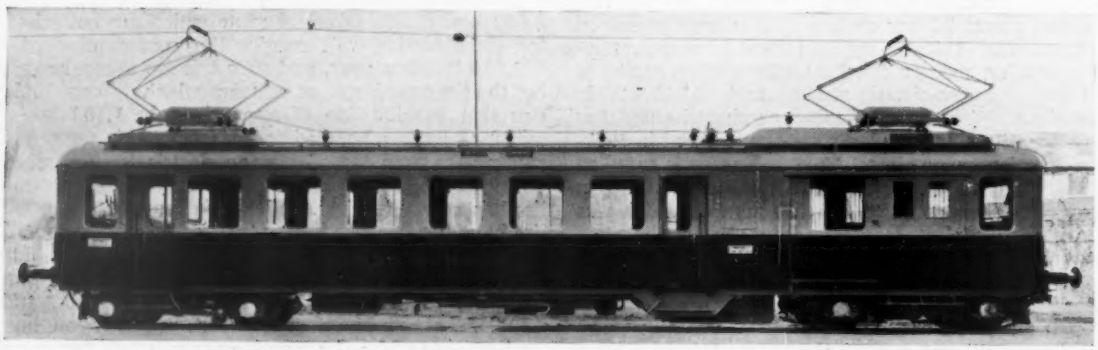
The new 12,000 h.p. Gotthard locomotive built by Oerlikon and the Swiss Locomotive & Machine Works is completed, and is on show at the Swiss National Exhibition, but in addition the Federal lines have acquired two new double-bogie electric locomotives, the first of this type on the single-phase Swiss Federal system. The single-unit Red Arrow fast motor-coach design has been developed into a twin-car articulated set with first and second class accommodation and a buffet, so that for high-speed journeys over the electrified section the Federal Railways now have single and twin-unit motor-coaches, and the powerful triple-car sets.

On the Rhaetian Railway, hitherto worked exclusively by locomotive power on the 15-kV single-phase principle, four new light-weight motor-coaches are to be put into traffic, in order to accelerate the services, particularly over the most heavily-graded lines. They should also reduce current consumption, for on the type of service operated between Landquart and Davos they will be able to haul a train with a seating capacity of 215 on a tare weight of 70 *tonnes* including the motor-coach itself, whereas with the existing C-C locomotives the weight is almost 130 *tonnes* for the same capacity. The new motor-coaches are to have four 150 h.p. motors with spring drive, and will have 51 second and third class seats (including emergency seats) on a tare weight of 35 *tonnes*. The top speed is to be 40 m.p.h., the maximum allowed anywhere on the metre-gauge Rhaetian system. Electric braking is being incorporated, and when applied the single-phase traction motors will operate as separately-excited d.c. generators, the energy from which will be dissipated in resistances; the braking force will be closely regulated by adjustment of the exciting circuit. Brown Boveri is acting as main contractor, and the electrical equipment is being made by that firm and by Oerlikon. The bogies are to have a wheelbase of 7 ft. 10½ in. and will be pitched at 42 ft. centres; over buffers the motor-coaches will measure 59 ft.

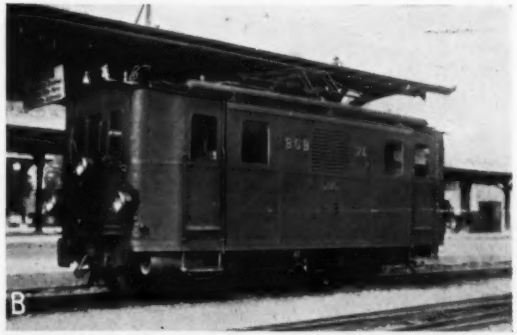
The standard-gauge Uetliberg Railway, which shares the Selnau station at Zurich with the Sihltal Railway, has acquired a new all-metal light-weight motor-coach taring 25 *tonnes*. It has a driving position at each end and is fitted with electro-magnetic track brakes and Knorr compressed air brakes. Two new bogie aluminium trailers have also been put into traffic; they have bogies with a wheelbase of 5 ft. pitched at 21 ft. 8 in. centres and tare 10 *tonnes*. The Uetliberg line is only 8 km. long and climbs out of Zurich at grades of 1 in 15 to 1 in 19, steepening near the summit to 1 in 14·3, most of it round sharp curves. It is operated on the 1,200-volt d.c. system, and as the Sihltal line is on the h.t. single-phase system the Uetliberg cars have bow collectors mounted to one side of the roof in order to give adequate clearance in and near Selnau, for both railways use the same track for the first three-quarters of a mile or so.

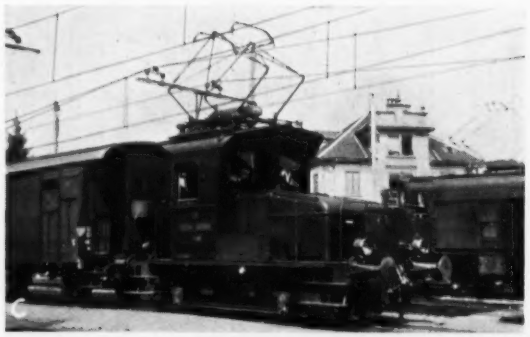
For use over the Sensetalbahn, connecting Gümmenen with Flamatt in the neighbourhood of Berne, which was built in 1902-03 and electrified in 1938 at a cost of 465,500 fr. including stock, an up-to-date single-phase motor-coach has been supplied by Sécheron. One driving bogie with two motors is fitted below the luggage compartment end of the motor-coach; at the other end is a simple carrying bogie, which, like the driving unit, is of the swing bolster type and is built up mainly by welding. The two traction motors drive the 37-in. wheels through Sécheron quill drive having a gear ratio of 1 : 5·25; they have a combined one-hour output of 450 h.p. at 28·3 m.p.h., giving a tractive effort at the wheel rims of 5,900 lb. On the continuous rating the aggregate output is 390 h.p. at 31·5 m.p.h., when the tractive effort is 4,600 lb. The maximum tractive effort at starting is 11,850 lb.; the adhesion weight 28 *tonnes;* and the top speed 46·5 m.p.h. Of the empty weight of 39·2 *tonnes*, 27·2 *tonnes* represents the weight of the mechanical portion.

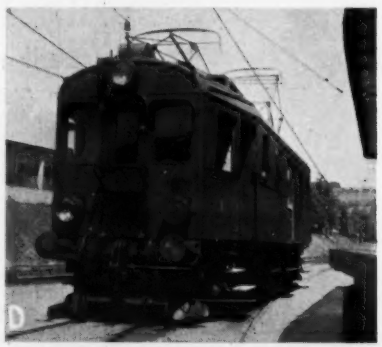
Accommodation for 60 seated and a maximum of 70 standing third class passengers is provided, together with luggage room, within an overall length of 65 ft. 6 in. The bogies have a wheelbase of 8 ft. 10 in. and are pitched at 45 ft. 5 in. centres. Electric resistance braking is incorporated, in addition to air and hand systems applying two blocks to each wheel, and the control gives 15 power and 13 braking notches. The wheels themselves are of the light tyred type as first evolved by Uerdingen and Bochumer Verein, and the axles run in S.K.F. roller bearings supported by helical steel springs with a short compensating beam beneath. Up the maximum grade of 1 in 31 the motor-coach can haul 70 *tonnes* of trailers, and along the level 120 *tonnes*. For the few months between the conversion of the line and the delivery of this coach, traffic was operated by one of the old Seetal C-C locomotives loaned by the Federal Railways.

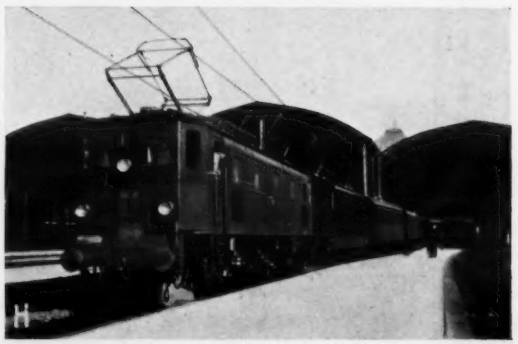


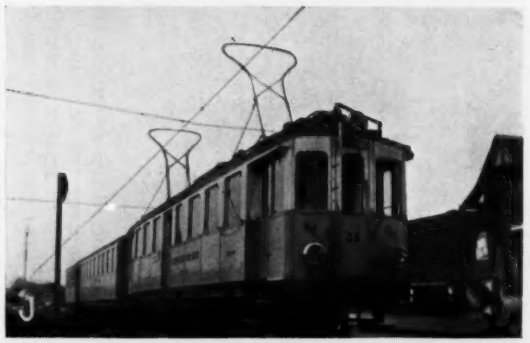
A new 450-h.p. 39-ton single-phase motor-coach for one of the Swiss private railways











(A) *One of the original 5·5-kV 25-cycle Seetal locomotives now running on the standard 16⅔-cycle lines.* (B) *C-type Bernese Oberland locomotive at Interlaken Ost.* (C) *One of the four-wheeled 15-kV single-phase shunters, Swiss Federal Railways.* (D) *Motor-coach on the Wohlen-Meisterschwanden Railway.* (E) *A Federal Railways' 2-Co-1 electric locomotive at Montreux.* (F) *One of the Uetliberg Railway motor-coaches with side-mounted pantograph to clear the Sihltal overhead wires.* (G) *Vallorbe train at Argentieres, ex-P.L.M. Railway; the line joins with the Swiss line to Martigny.* (H) *Double-headed passenger train on the Swiss Federal Railways at Lucerne.* (J) *Motor-coach hauling trailers on the United Berne-Worb Railways*

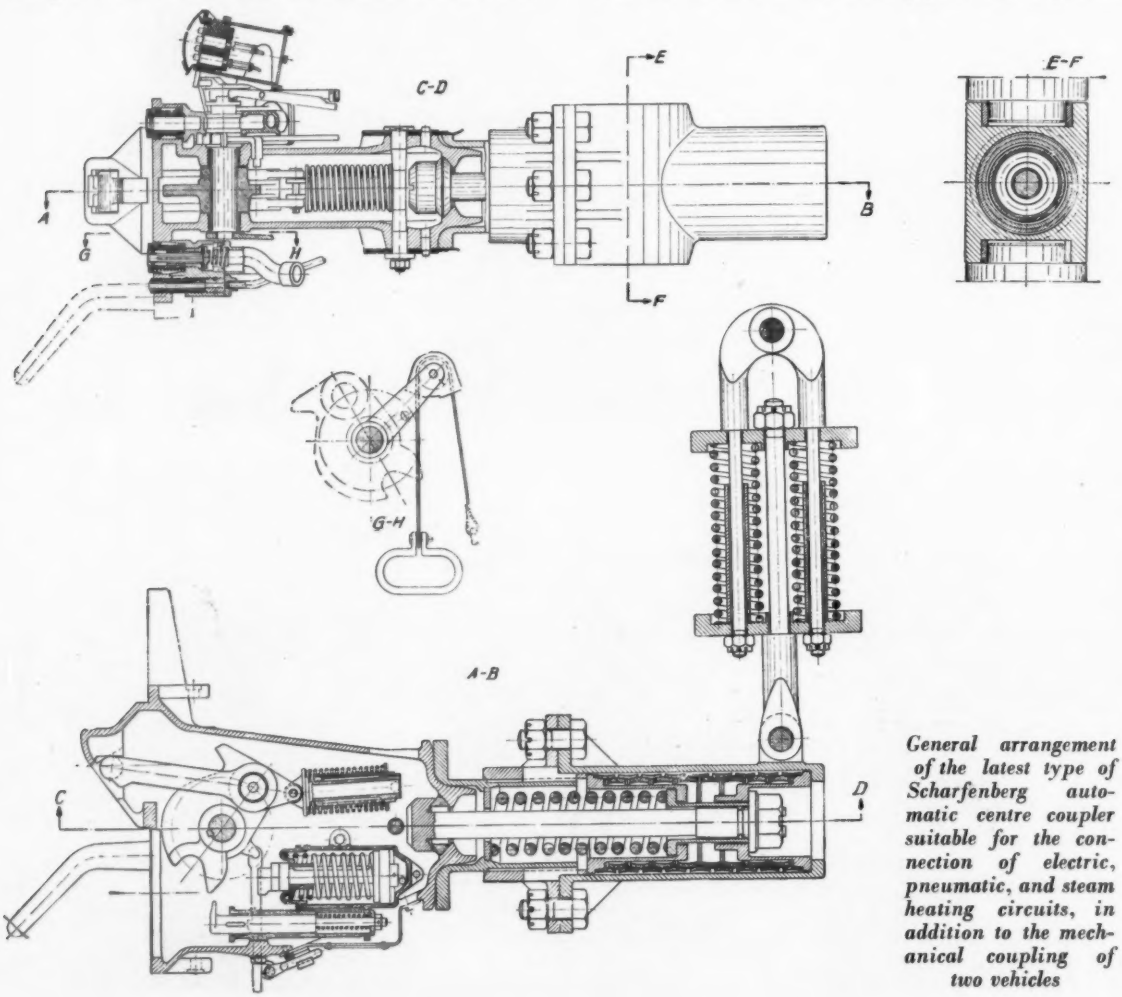
THE SCHARFENBERG MULTI-PURPOSE COUPLING

IN all the latest applications of the Scharfenberg automatic multi-purpose centre coupler used for electric and diesel stock the connection of the electric and pneumatic circuits is effected automatically as well as the mechanical coupling. A device for automatically opening and closing the air brake pipes is included, and the release of the coupler itself is effected through compressed air controlled from a handle in the driving position. Automatic steam heating connections can also be incorporated.

The manipulation of the cable connection, arranged above the main coupler is effected by the movement of the coupler lock in the head. The control over the movement of the cable connector, which is turned back when the coupler is free, is such that at the same time as the connector moves forward the cover lifts up and frees the contacts, which are arranged on spring supports. The movement takes place so rapidly, under the influence of a powerful spring, that the contacts come together with a snap, and no arc can form. A connector can contain up to 70 contacts. In order to keep contact resistance, which increases with even slight oxidation of brass contacts, to a minimum, the contact surfaces are silvered. This is especially necessary in the case of line wires going to measuring instruments, as otherwise oscillation of the indicating needles cannot be avoided when running, on account of the spring contacts rubbing on each other.

In the coupled up condition the contact members are protected against moisture and brake dust by rubber packing pieces round the edges, which are pressed together. The position of the cable connector with respect to the buffer surface line of the main coupler can be accurately regulated by an adjusting screw. In order to be able to isolate faults which may occur in the electric (*e.g.*, multiple-unit) control and to disconnect the defective vehicle electrically, the cable connector can be put in and out of engagement by hand without the main coupler having to be uncoupled. Disconnecting in this manner frees the positive connection between the coupling lock of the main coupler and the cable connector, so that when the main coupler is actuated the latter remains unaffected. The contact terminals are easily accessible for repairs. By undoing two hexagon screws the connector can be tilted forwards, leaving the rear face of the terminal box free when the cover is removed. There is a cable lead in on each side of the connector, providing a standard type for general service although only one lead in is ordinarily used.

The cut-off cock in the brake pipe is also dependent in



General arrangement of the latest type of Scharfenberg automatic centre coupler suitable for the connection of electric, pneumatic, and steam heating circuits, in addition to the mechanical coupling of two vehicles

its movements upon the coupling lock in the main coupler. From this arises the necessity of holding the lock in its end position when the coupler is uncoupled, differing from the practice hitherto. When the coupler is uncoupled the lock becomes spring-loaded and a catch secures it in its end position. At the instant that two coupler heads come together, the nose piece of one entering the recess in the other pushes back a trigger which frees the catch.

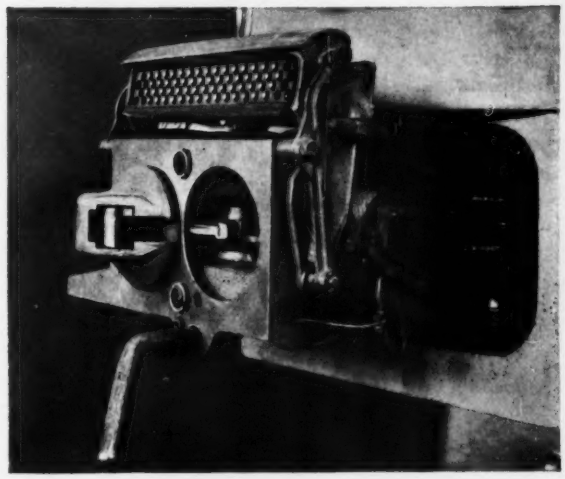
Brake Connections

The locks of the two couplers assume the coupled condition under the action of the springs. On the extended spindle of the main piece of the coupler a striker is keyed, which actuates the brake pipe cut-off cock. In the uncoupled condition this striker presses the valve on the rubber packing ring against a spring, so that the valve disc keeps the brake pipe closed. In the coupled condition the valve disc keeps the valve body closed to the outside under the pressure of the spring. This arrangements renders a packing gland for the valve spindle unnecessary.

In order that an emergency application may be made if a coupling was to break through some fault, the air brake pipe must not be closed. This is achieved because, on coupling, the valve is opened by the closing mechanism of the coupler, but on uncoupling it is not moved by the closing mechanism itself. This movement is carried out by the rod of the piston in the releasing cylinder, which also turns the closing mechanism of the coupler to the disengaged position. Thus the stop cock of the main brake pipe is closed only when the coupling is disengaged by handling the releasing cylinder, *i.e.*, intentionally.

For releasing the coupling by air a releasing cylinder is provided in the coupler head. The free end of the releasing piston rod is formed as a push piece, or buffer, and under the action of the air in the cylinder this pushes the coupling lock along until, at the end of the stroke, the spring is under tension and the locking catch engaged. After a brief interval the releasing cylinder becomes exhausted and its piston returns to normal under spring power. When two couplers are being disconnected both cylinders are operated to bring the coupling locks in both heads into their end positions, in which condition alone the main air pipes are properly shut off. To avoid having to use the release device on both vehicles the releasing cylinders of two connected couplers are joined together through a special equalising pipe, the mouthpieces of which are arranged beneath the main reservoir pipe. To operate this device a release cock is fitted in the driver's compartment through which, when it is in the uncoupled

Emergency slip-on coupler for connecting standard hook coupling to Scharfenberg apparatus



Front of Scharfenberg coupler showing at the top the electrical connector with 70 contacts

position, air passes to the releasing cylinder. The latter is exhausted once more when the cock is returned to its normal position. Unauthorised actuation of the cock is prevented by a lock, which can only be opened by the key of the driver's brake valve. In order to uncouple two vehicles easily from a platform, or when they are standing in storage sidings, without having first to go into the driver's compartment, a releasing valve is provided outside on each end of the vehicle. By pressing on the valve head with the hand, or with the foot from the platform, a connection is established between the main reservoir air pipe and the releasing cylinders. The air pipe connecting the various main reservoirs is also operated automatically by means of a valve in the pipe mouthpiece.

To permit of the coupler being uncoupled should the air releasing device fail (*e.g.*, through want of air) a wire-pull and handle are provided, enabling the coupler heads to be disengaged by hand.

The coupler head proper is connected by a link with the coupler spindle. Spring sheet covers, which engage with the shaft above and below, prevent the head from turning. The spindle is mounted, free to turn, in two vertically placed pins secured to the vehicle underframe. A spring bearing on the spindle centralises the parts. The spring transmitting the push and pull forces is arranged in the hollow coupler spindle. It consists of a spiral spring as preliminary load spring and a ring form spring of about 30 *tonnes* full load as main spring.

Emergency Coupling

In order to couple, in cases of necessity, a vehicle equipped with the Scharfenberg coupler to a locomotive or vehicle fitted with the ordinary screw coupling, a special slip on and off coupling piece has been developed. It can be applied to any coupling hook and rests on the end face thereof through a spring buffer. As it has no guide nose and therefore does not possess the same limits within which two coupler heads can always engage with one another correctly, it has to be brought into the right position by hand after being placed on the hook. When this subsidiary coupler is brought into engagement with a Scharfenberg equipment the coupling is actuated automatically. Its release is effected by the hand pull attachment on the Scharfenberg coupler. Every vehicle fitted with that coupler which can run singly in service is provided with the subsidiary attachment, enabling it to be coupled to a screw coupler at any time, if required.

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12,000-H.P. ELECTRIC LOCOMOTIVE

Twin-unit design for the operation of heavy express passenger trains and freight trains over mountainous grades on the single-phase Swiss Federal Railways. This locomotive is now on view at the Swiss National Exhibition at Zürich

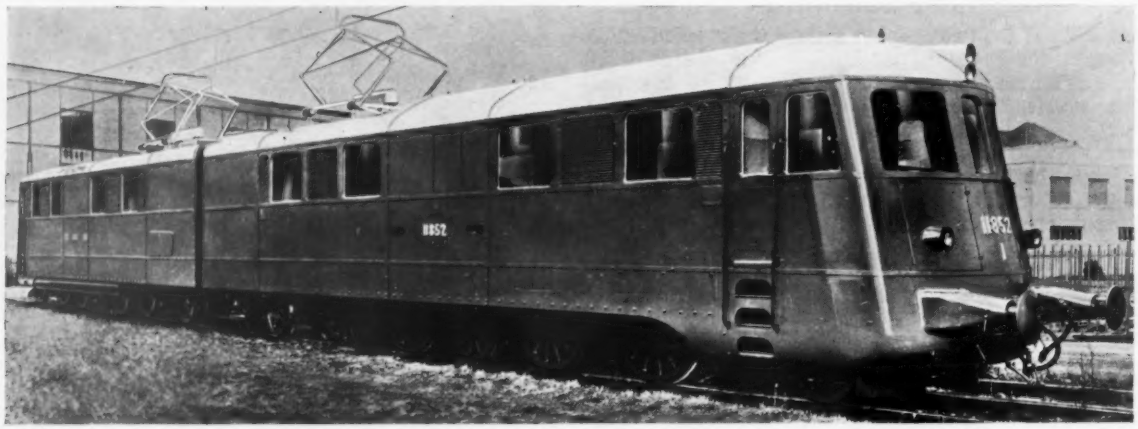
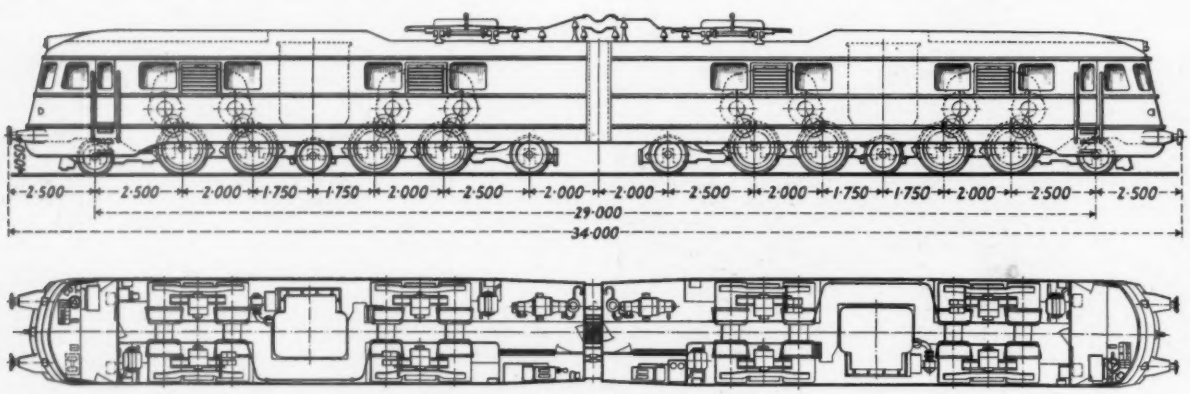


Fig. 1.—The exterior of the latest Swiss single-phase electric locomotive with a maximum axle-load of 20 tons and a total weight of 230 tons

MORE than eighteen months ago the Swiss Federal Railways placed an order for a new high-power electric locomotive for the Gotthard line, which in output was to exceed that of the two locomotives built for the same route in 1932 by 38 per cent., and which would be more powerful than any other electric locomotive in the world. This locomotive was completed at the end of April last, and at the beginning of May was sent to the Swiss National Exhibition at Zurich. It was built to the requirements of M. G. Steiner, Chief of Electric Motive Power, Swiss Federal Railways, by the Maschinenfabrik Oerlikon and the Schweizerische Lokomotiv-und Maschinenfabrik, the former being responsible for the electrical equipment and its erection in the locomotive, and the Winterthur firm for the mechanical portion.

The new locomotive is similar in many respects to the Oerlikon 6,480-kW electric locomotive No. 11851 put into traffic on the Gotthard route in 1932, and which has now run over 600,000 miles, but the designers were able to increase considerably the output of the electrical equipment, partly by reason of progess in design and partly because of the adoption of the modern I.E.C. ratings in place of the old Swiss Federal Railways specified ratings. Actually the great increase in output has been obtained with a decrease in weight, for the electrical equipment of the latest locomotive weighs 247,500 lb. compared with the 258,000 lb. of the 1932 machine.

Numbered 11852, and designated Ae 8/14, that is, eight axles out of 14 are driven, the new locomotive has the same wheel arrangement as its prototype No. 11851, *viz.*, 2(1 – Bo – 1 – Bo – 1). It consists of two close-coupled halves which are always connected in service, and which are nearly identical to one another. The control is from either of the two driver's cabs, located one at each end of the locomotive. Single-phase current at 15 kV, $16\frac{2}{3}$ cycles is collected from the overhead wire by two pantographs. The driving wheels have a diameter of 53·3 in. and the carrying wheels 37·3 in. The wheelbase particulars may be obtained from the accompanying diagram. In com-



Figs. 2 and 3.—General arrangement and layout of the largest standard-gauge Swiss locomotive

plete working order the weight is 513,300 lb. (230 tons), of which the electrical equipment accounts for 247,500 lb. (110¾ tons), the mechanical portion for 263,000 lb. (118 tons), and the sand, tools and crew for 2,800 lb. (1¼ tons).

The total adhesive weight is about 158 tons, the driving axle load being 44,000 lb. The locomotive can haul express trains with a weight of 600 tons, exclusive of the weight of locomotive, on the gradients of 1 in 38-40 of the Gotthard line at a speed of about 40 m.p.h. Freight trains of about 750 tons trailing can be hauled on the same gradients at about 31 m.p.h. The two one-hour ratings of the locomotive correspond respectively to wheel-rim tractive efforts of about 88,000 lb. at a speed of 46·6 m.p.h., and 97,000 lb. at 44·5 m.p.h.; the maximum tractive effort normally is about 110,000 lb. In order to make it possible to use this high tractive effort effectively at starting, it is necessary that the adhesive weight should be raised from 158 tons to about 169 tons, or to individual driving axle loads of 47,500 lb. This is done in a very simple way, by transferring weight from the middle carrying axles, by means of a compressed air weight-shifter. The maximum starting tractive effort permitted by the electrical equipment is 140,000 lb., which can be maintained up to a speed of 39 m.p.h. But related to the maximum adhesion weight of only 169 tons, this tractive effort gives a factor of adhesion of only 2·7, compared with 3·9 on the maximum one-hour rating. In view of these low ratios an electrically-operated wheel-slipping indicator is fitted in the driving position.

Electrical Equipment

Only two pantographs, of a lightweight type, are used, and this in conjunction with the smooth exterior of the locomotive, has considerably improved the appearance compared with the locomotive built in 1932. The high-tension circuits are shown in Fig. 8, in which will be noted the two disconnecting switches 2*a* and 2*b* and the two-pole earthing switch 4 which enable either of the two pantographs or two main transformers to be cut out at will. In each driving position is a wireless line-voltage indicator, which shows the driver whether the contact wire is under voltage or whether the line is dead, without the pantographs being raised. This equipment was developed because of cases where a driver had raised his pantograph several times on a section of line which was temporarily dead, and had used up all the compressed air, the collector finally having to be raised by hand pumping when the line did become live. The line voltage indicator is

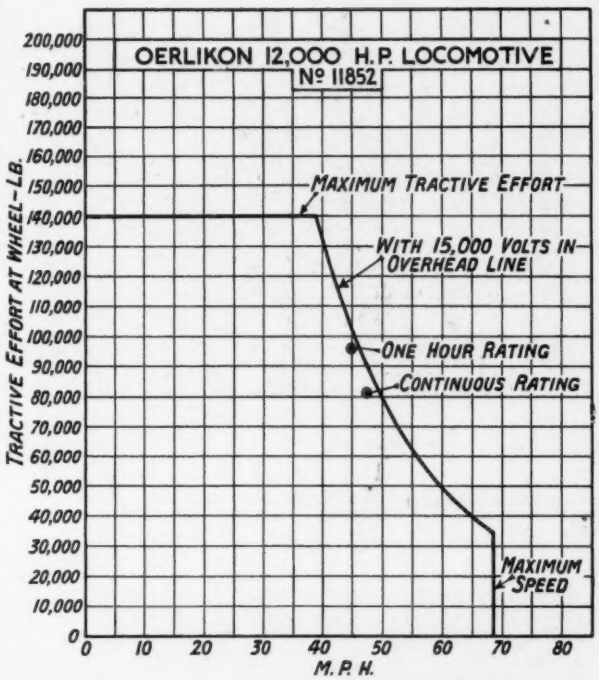


Fig. 5.—Rail tractive effort curve of the new 230-ton Gotthard electric locomotive

Fig. 4.—Interior of driving cabin showing the electric heating coils on the front windows to prevent frosting

in the form of a radio tube similar to that used in wireless reception sets, and a 7-ft. aerial for each indicator is carried on the locomotive roof. Operating current is furnished by a 36-volt battery. Current in the catenary systems of adjacent tracks do not influence this apparatus.

For the speed control of the double locomotive, a newly evolved h.t. control is used, in which the secondary pressure is regulated on the primary side of the locomotive transformers. In view of this, only relatively small currents have to be dealt with, whereas pressure regulation on the low-tension side of the transformers would have entailed the use of cumbrous control gear for several thousand amperes. Such gear would necessarily have been very heavy and required much more space than the h.t. gear. The only low-tension switchgear within the apparatus rooms are the reversers and one electro-pneumatic unit switch for each traction motor group. At the inner end of each unit is a switchboard for the auxiliary circuits and the protecting relays of the locomotive. Each half of the locomotive is furthermore equipped with an air-brake compressor of approximately 82 cu. ft. per min. capacity at a pressure of 115 lb. per sq. in.

The transformer being the heaviest single piece of apparatus it was natural to arrange it near the centre of the half locomotive, in an endeavour to gain the most favourable riding conditions. The increase of 26 per cent. in the rating (to 7,300 kVA) compared with that of the

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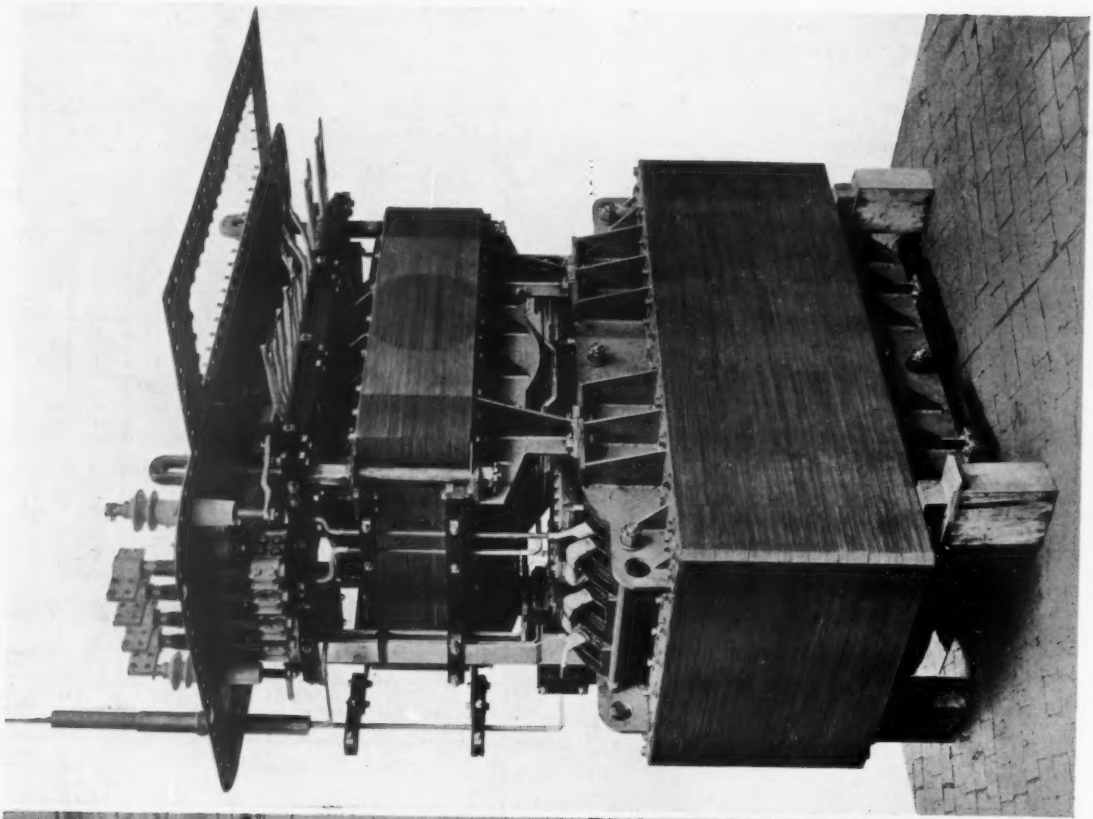


Fig. 7.—Main transformer of one-half of the new Gotthard locomotive, with tank removed. The capacity is 7,300 kVA

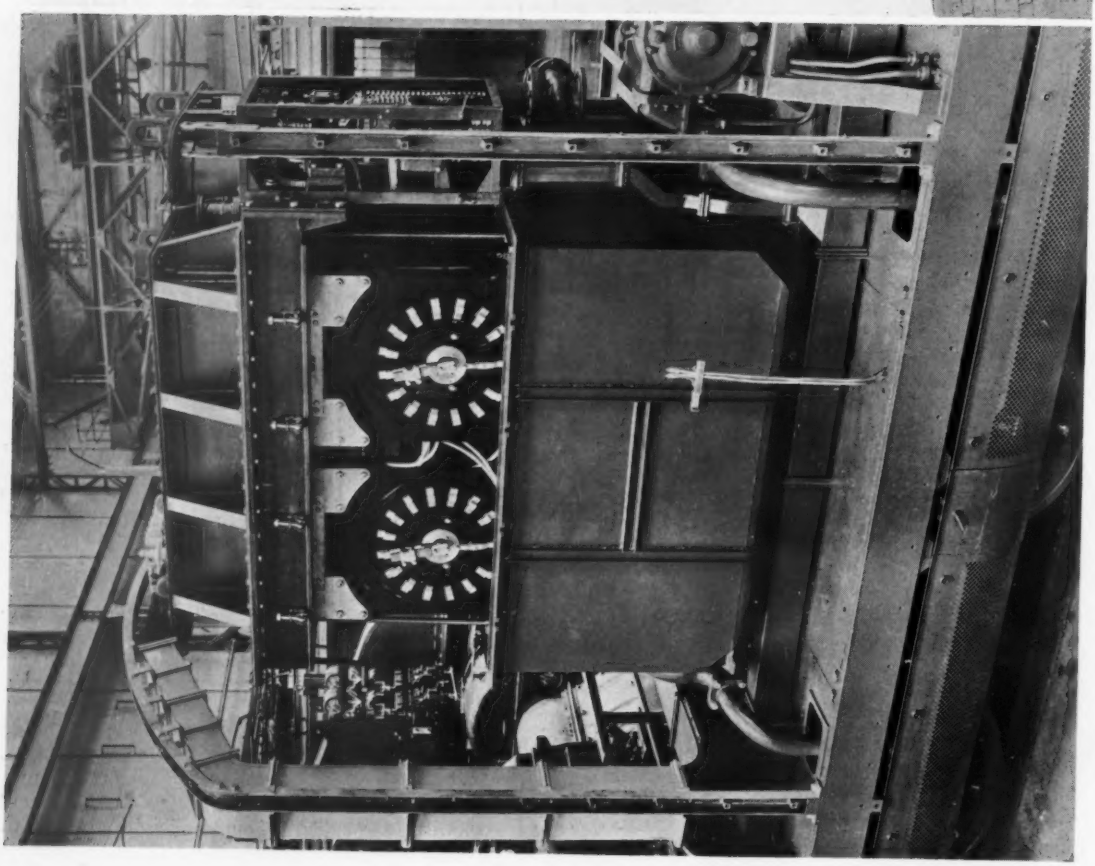


Fig. 6.—Transformer being installed in the locomotive; the top half of the tank has been removed to show the tap-changing mechanism

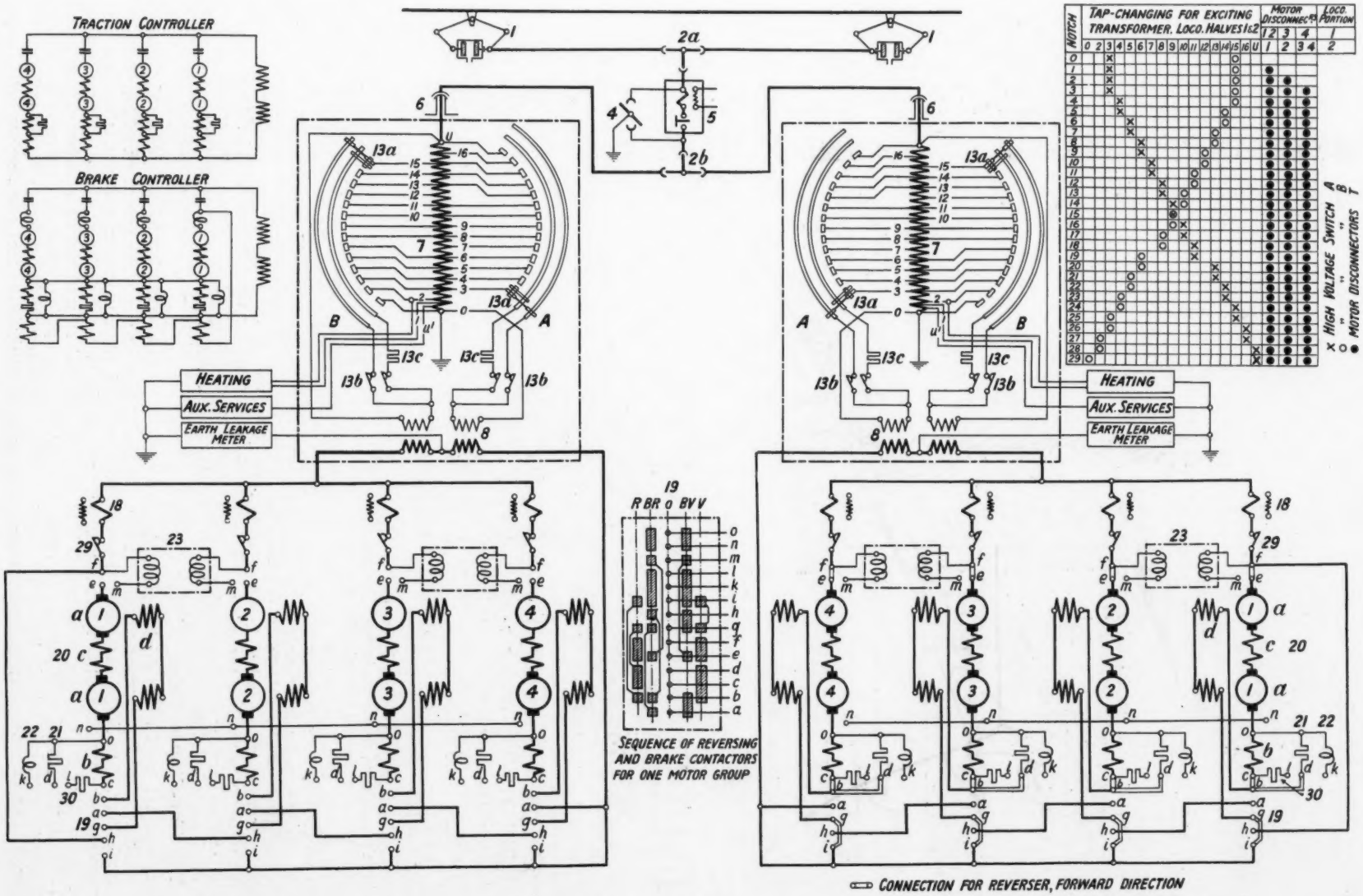


Fig. 8.—Diagram of main power circuits of the 2(1-Bo-1-Bo-1) express single-phase locomotive, Swiss Federal Railways

This diagram shows the circuits of the locomotive halves coupled

1932 locomotive has been obtained with an increase of 15 per cent. in the weight.

Each transformer set consists of one regulating and two secondary transformers. For reasons of simplicity and weight limitations all three transformers are placed in a common oil tank. The high-tension tap-changer, however, is located in a special oil tank adjacent to the transformer tank, but there is no connection between the two oil tanks. The design of the entire transformer group and tap-changer is such that all high-voltage connections are inside the tanks.

Two tap-changers connected to each transformer set are alternately operated by a special drive mechanism, and supply the secondary transformers with voltages taken from the taps of the regulating transformer in such a way that a total of 29 running steps result. The arrangement provides this number of running steps with only half the number of taps on the regulating transformer. The regulating transformer is built with the following taps:—

1.—	0	volts—Connection to earth (rail).
2.—	230	,, Tap for auxiliary services—about 80 kVA.
3.—	840	,, Tap for heating circuits.
4.—	1,050	,, First running step and tap for heating circuits of 450 kVA.
5.—	2,290	,, Running step.
6.—	3,530	,, ,, ,,
7.—	4,650	,, ,, ,,
8.—	5,380	,, ,, ,,
9.—	5,980	,, ,, ,,
10.—	6,620	,, ,, ,,
11.—	7,440	,, ,, ,,
12.—	8,610	,, ,, ,,
13.—	9,430	,, ,, ,,
14.—	10,070	,, ,, ,,
15.—	10,670	,, ,, ,,
16.—	11,400	,, ,, ,,
17.—	12,500	,, ,, ,,
18.—	13,760	,, ,, ,,
19.—	15,000	,, ,, ,, (connection with pantographs).

In Fig. 7 is shown the construction of the three transformers arranged in a solid unit. The low-tension windings of the two secondary transformers are always connected in series. The transformer tank is considerably reinforced to withstand the vibrations and shocks to which it is subjected in service, and the transformers are cooled by forcing the oil through fan-cooled radiators. An oil-circulating pump of simple design ensures a continuous flow of oil through the radiators; it is of a design developed years ago by Oerlikon for stationary transformer plants, and does not contain any stuffing boxes; the motor as well as the pump itself is entirely filled with oil.

High-Tension Switchgear

Each of the tap-changers consists of two units of plate-type selectors, the contacts of which are arranged in a circle. Fig. 6 shows the assembly of the transformers, tap-changers and tap-changer drive. In order to ensure a smooth transfer from one tap to the other, a transfer resistor is used, which is only in circuit during the transfer, its losses being thus reduced to the minimum. To prevent the contact arms from interrupting the circuits, four arcing switches are built into each tap-changer; they are cam-operated and are connected mechanically with the contact arms in such a way that the latter never interrupt the current. The high number of running steps (29), results in comparatively small tractive effort increases when switching from one step to another, and the start of the locomotive is therefore smooth, and the speed regulation flexible.

Tap-Changer Drive

Each tap-changer set has its own driving mechanism, operated normally by a small d.c. motor connected to the 36-volt storage battery. In Fig. 9 are shown the electrical connections of the remote control system. Each driving position is fitted with a master-controller. If either of the two master-controllers is moved to a certain position, the driving motor built into the tap-changer drive operates it until the tap-changer has reached the corresponding position. The electrical arrangement is such that the tap-changers of both locomotive units always reach identical steps at the same moment, otherwise the load would not be evenly distributed between the motors of the two locomotive units. The design of the tap-changer is quite simple, and consists mainly of the master-controller 150 (Fig. 10), the d.c. driving motor 158 with brake 162, two control relays 160a and 160b (for " up " and " down " movements), one sequence controller 165, and several auxiliary switches. The tap-changers can also be operated manually from the driver's cab or at the driving mechanism itself.

Manual operation is only possible for the tap-changer located in the same locomotive-half as the manual control

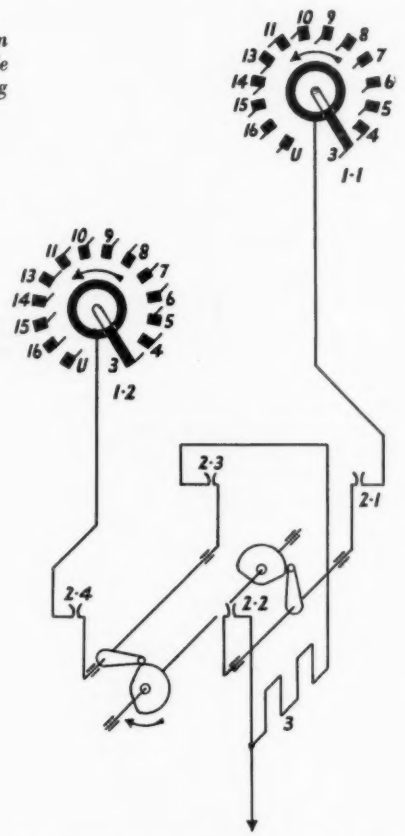


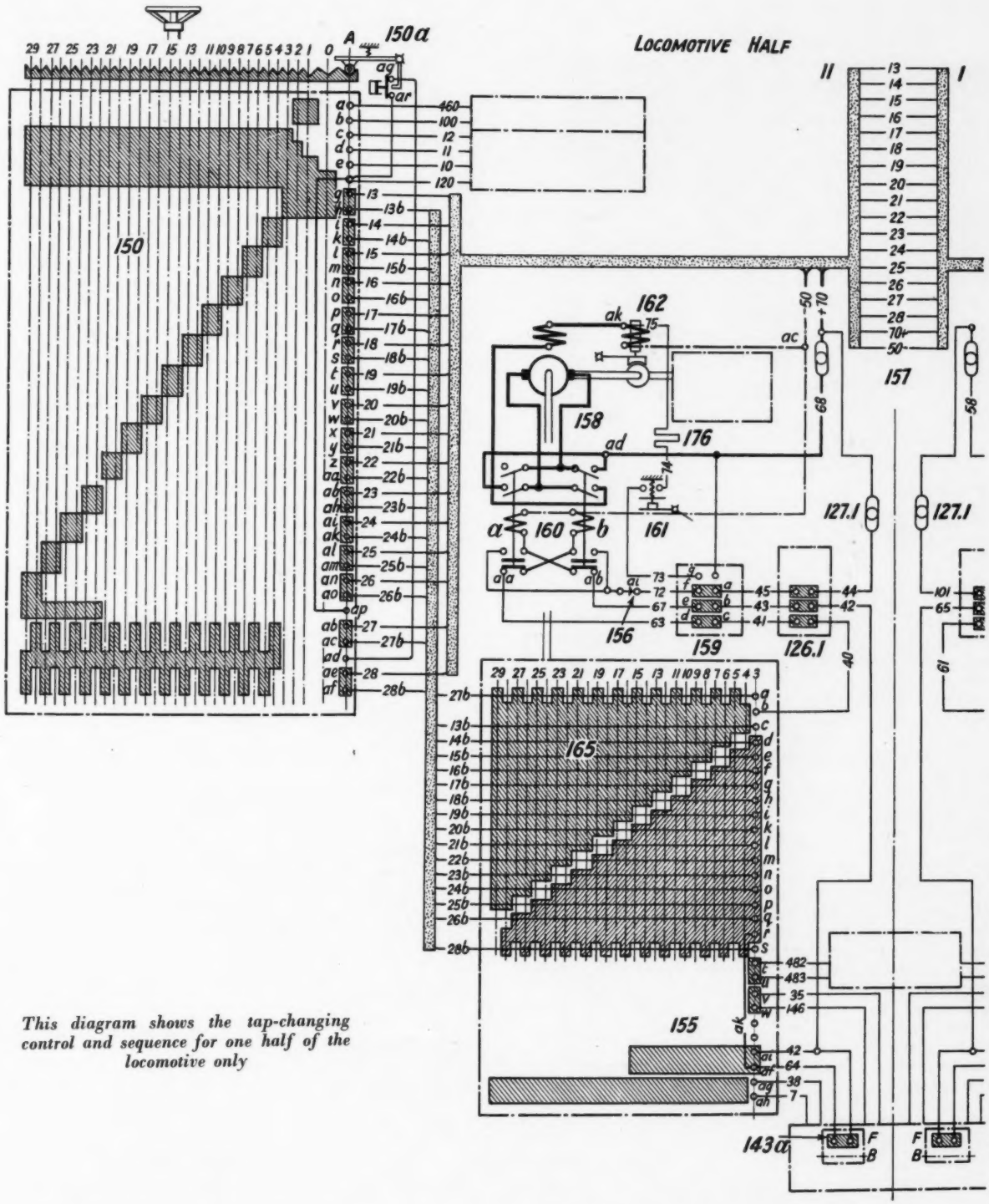
Fig. 9.—Diagram showing the principle of the tap-changing control

(1) Tap selector
(2) Load switch
(3) Resistance

gear. Nevertheless it is possible to operate the rear unit manually, while the front unit is remotely controlled from its master-controller. The driver, when operating the rear unit, has merely to observe the voltmeters and ammeters arranged in the corresponding driving cab and then move the tap-changer to a position that results in approximately the same voltage and motor current as those shown by the instruments for the other unit. Fig. 11 shows the tap-changer drive, and this driving mechanism is very easily accessible in the locomotive itself as can be seen in Fig. 6.

Traction Motors

The 16 traction motors, as shown in Fig. 13, are of the compensated single-phase series commutator type with phase-displaced commutating pole field. Forced ventilation is provided by means of motor-driven fans arranged on top of the traction motors themselves. The central passage-way down the locomotive makes the motors easily accessible, particularly the commutators and brush-



This diagram shows the tap-changing control and sequence for one half of the locomotive only

126·1	Isolating switch for control current
143*a*	Reverser locking contact
150	Controller
150*a*	Spring contact
127·1	Control current fuse
155	Locking contact for sequence switch
156	Motor switch
57	Fuse for sequence switch motors
158	Drive for sequence switches
159	Locking contact for manual control
160*a*	Control relay for sequence switch motor
160*b*	Control relay for sequence switch motor
161	Foot-operated dead-man control
162	Air brake control magnet
165	Sequence controller
176	Resistance for air brake magnet

Fig. 10.—Schematic diagram of the tap-changer drive and sequence of one half of the new twin-unit 12,000 h.p. single-phase Gotthard locomotive of the Swiss Federal Railways

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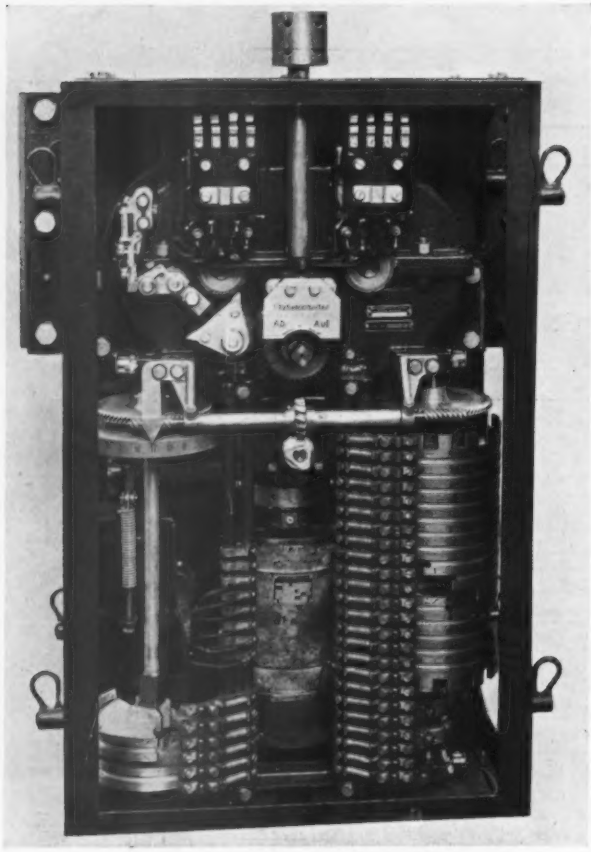
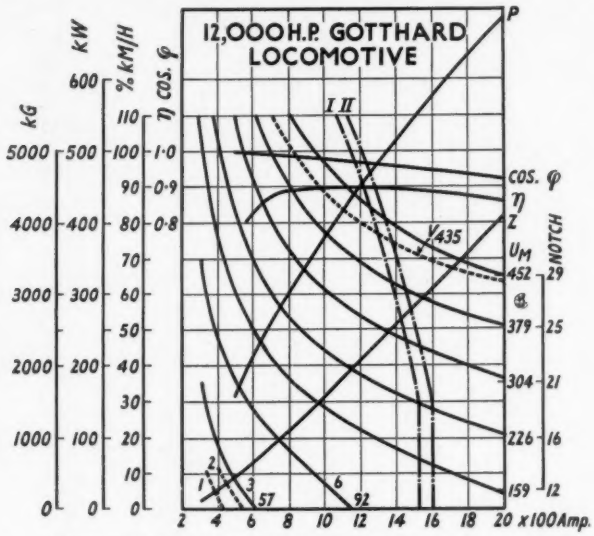


Fig. 11.—Tap-changer drive erected in its casing, and with the cover removed

holders, which can be inspected easily when the commutator cover has been removed. A rotating brush rocker permits the supervision of all brushes, even those normally located in the inaccessible lower part of the motor. Parts withstanding heavy mechanical stresses, such as housings, bearing shields and rotor-spiders, are made of cast steel, but wherever practicable, aluminium alloys have been used. This, combined with cast steel and welding, has resulted in a construction that has permitted appreciable weight reduction. The characteristic curves of the motors are given in Fig. 12, and—in aggregate for the complete locomotive—the powers are given in Table I, which as a matter of interest includes the corresponding values for the Oerlikon-built locomotive No. 11851 of 1932.

Only mica has been used for the insulation of the commutator and motor windings. In order to suppress higher harmonics, the rotor slots are slanted by one slot pitch. For the testing of the insulation values of the traction motor circuits there is an earthing current ammeter, the circuit of which is closed by the push-button switch. A current limiting resistance protects the instrument in case of a direct earth connection somewhere in this circuit. This test can be made at any time, even when the locomotive is in operation. The traction motor circuit is earthed by means of a protecting resistance in such a way



ρ Output at wheel rims in kW, with 435 volts constant at motor
Z Tractive effort at wheel rims, in kg.
V Speed in km.p.h. with 15 kV in contact line ($n = 13{\cdot}6 \times V$)
V Speed in km.p.h. with 435 volts constant at motor
cos φ Power factor with 435 volts constant at motor
η Efficiency with 435 volts constant at motor (Gear losses according to A.I.E.E.)
Um Voltage of motor with 1,300 amp. current (notches 1 to 6; at rest)
I Continuous current as function of the speed
II One-hour current as function of the speed

Wheel dia. 1,350 mm.
Gear ratio 1 : 3·47

Fig. 12.—Characteristic curves of one 750-h.p. single-phase traction motor

that the highest service voltage of any part in this circuit is never more than the voltage of one motor, *i.e.*, about 450 volts at its highest value. In order to cut out one traction motor set, it is only necessary to interrupt the control circuit of its pneumatic unit switch.

The two motors connected to each driving axle are permanently connected in series in the motoring as well as in the regenerating combination. The four such motor groups of each locomotive-half are continuously connected in parallel. Each motor group is fitted with an electro-pneumatically operated unit switch, which closes the motor circuit each time the master controller is moved from the zero to the first operating position; it opens the circuit

TABLE I.—TRACTION MOTOR RATINGS, OERLIKON GOTTHARD LOCOMOTIVES, SWISS FEDERAL RAILWAYS

—	Locomotive 11851 (1932)			Locomotive 11852 (1939)			
	One-hour	Cont.	Max.	One-hour		Cont.	Max.
Standards for determination of ratings	SBB	SBB	—	IEC–I	IEC–II	IEC–I	—
Output at motor shafts—H.P. ..	—	—	—	12,000	11,175	10,600	—
,, ,, ,, kW. ..	6,480	6,100	—	8,900	8,400	7,920	—
Tractive effort at wheel rim, lb. ..	81,000	72,500	132,000*	97,000	88,000	80,000	143,000*
Speed, m.p.h.	38·4	40·25	62*	44·5	46·5	48	68*

* Not in conjunction

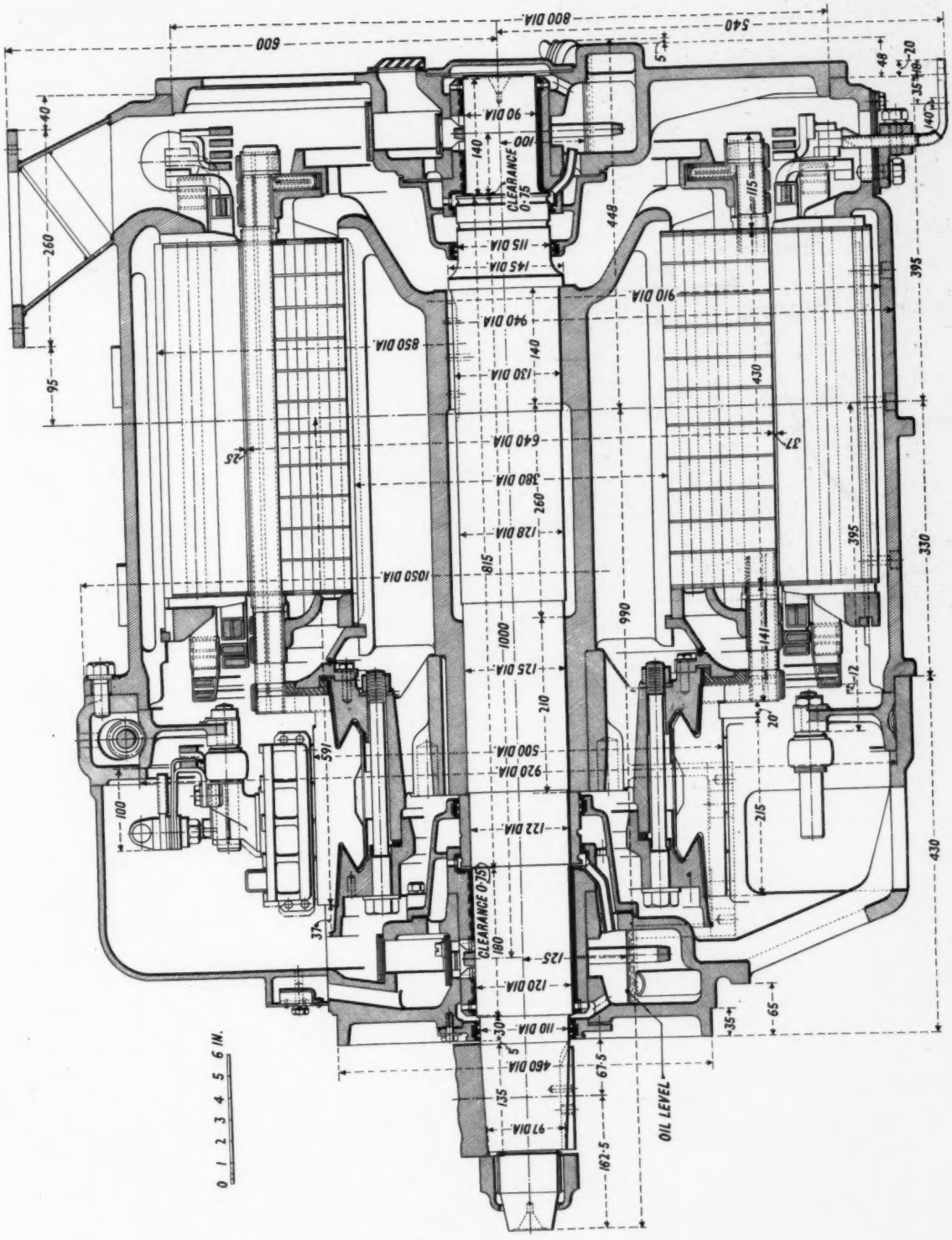


Fig. 13.—Cross-section through Oerlikon 750 h.p. 435-volt single-phase commutator-type traction motor, 16 of which are installed in the new twin-unit Gotthard locomotive running on the 15-kV. electrified system of the Swiss Federal Railways

again when the master-controller is moved to its zero position. Each motor group is furthermore fitted with a reversing-regenerating electro-pneumatically operated change-over switch, which never interrupts the power. The only principal electrical details in the low-tension traction motor circuits are one unit switch and one change-over switch for each motor group. It is this arrangement that makes the cab of the locomotive look so empty; all motor, auxiliary and control power cables are neatly tucked away.

The motor-blower group of each pair of traction motors is operated by a 17 h.p. 220-volts 2,000 r.p.m. single-phase series-type motor. Each locomotive-half contains four such blower groups. As it is not necessary to supply the same amount of cooling air under all operating and climatic conditions, arrangements have been made to permit two such groups to be connected either in parallel or in series; thus, two economical speeds are obtained. During winter time the fan motors are connected in series, operating consequently at about half of the normal speed;

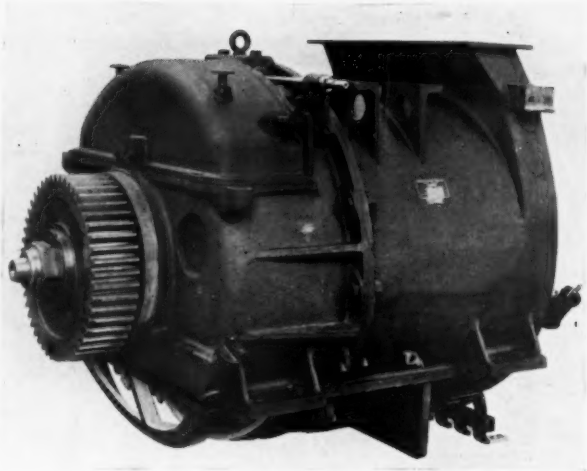


Fig. (14 *above*).—*750-h.p. force-ventilated Oerlikon traction motor and driving pinion. Two of these motors drive one axle through a centrally-located drive*

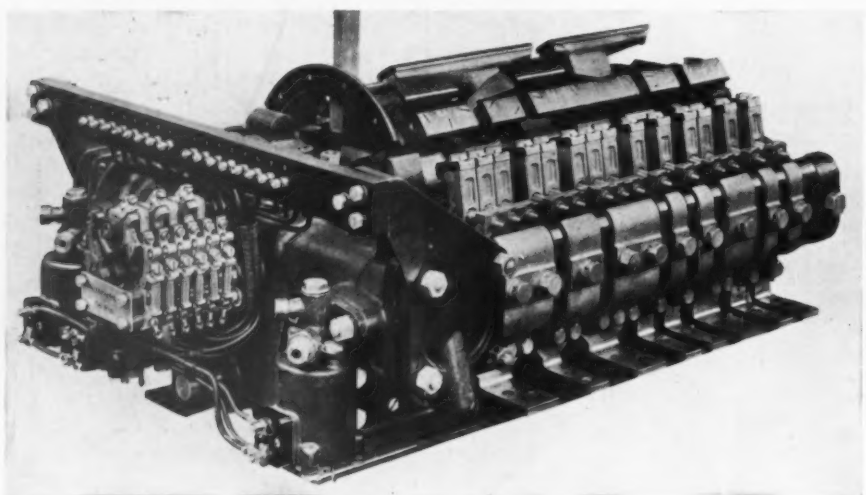


Fig. 15 (*left*).—*The reverser and the electric regenerative braking change-over switch as installed in the* 12,000-*h.p. Gotthard locomotive*

in summer time, however, they are operated in parallel, thereby furnishing the maximum amount of cooling air. The desired connections are obtained by a three-pole cam-operated series-parallel change-over switch, of which two are used in each unit. The same motor-blower groups are also used to cool the transformer oil, by blowing air through an oil cooler arranged between the louvres in the locomotive side walls and the entrance to the fan housing.

Torque transmission between the traction motors and the wheels is by means of individual axle drive on the SLM-Winterthur Universal system. This drive necessitates two motors arranged transversely within the locomotive above each axle. A double reduction gear with a ratio of 1:3·47 is incorporated, and as the two traction motors for each axle are connected mechanically they had to be connected electrically in series. The pinions on the inner ends of the motor shafts engage with others on an intermediate shaft below, and these drive the final gear wheel on the centre of the axle. The whole of the driving mechanism is enclosed in a dustproof casing and is adequately lubricated.

Relays

The main power and train-heating circuits are protected by overload relays which trip the main high-tension oil circuit-breaker, which is installed only in one half of the locomotive. In order to protect sufficiently the various circuits, the locomotive is equipped with the following relays:—

(*a*) Eight instantaneous maximum current relays for the traction motor groups.
(*b*) Two instantaneous maximum current relays for the train-heating circuits.
(*c*) Two voltage relays for the automatic starting of the motor-blower groups.
(*d*) Two interlocking relays for the tap-changer drive mechanism.
(*e*) One instantaneous minimum tension relay.
(*f*) One auxiliary time relay for relay (*e*).
(*g*) One shunt relay for relay (*e*).
(*h*) One minimum current time delay relay for the high-tension circuit.
(*i*) One blocking relay to prevent the tripping of the main oil circuit-breaker in case of heavy short circuits.

To reset the relays and to close the oil circuit-breaker again in the event of one of the above mentioned relays having tripped, it is necessary for the driver to move the master-controller to the zero position. This also initiates the " down " movement of the two tap-changers to the zero position. Only after this has been reached is it possible to reclose the high-tension oil circuit-breaker and then to feed the main traction motor and other circuits once more.

Regenerative Braking

As the locomotive is to be used mainly on the mountainous Gotthard line of the Swiss Federal Railways, it

was only natural that it should be equipped with some kind of electric braking system. The system adopted was developed by the late Dr. Behn-Eschenburg of Oerlikon; it has been used on a large number of single-phase locomotives and is claimed to be the only system that has been really extensively used on single-phase locomotives equipped with commutator motors. Its operation by the driver is extremely simple; all that has to be done to initiate regeneration is to move the master-controller to the zero position, turn the regeneration control handle from the motoring to the electric braking position, and then to advance the master-controller again to any desired operating position, but the driver must observe the ammeter of the traction motor circuits. Fig 17 shows the braking characteristic curves of the locomotive. From this it is obvious that a certain braking force corresponds to each braking step regardless of the speed of the locomotive, and this braking force remains practically constant over the entire speed range. The locomotive can be braked to a standstill.

In order to provide electric regeneration to such an extent that the entire locomotive weight can be braked electrically on the 1 in 37 grades, the equipment also includes four braking inductive coils; eight inductive commutating-pole shunts; and eight ohmic commutating-pole shunts. The weight of these details is about six tons, *i.e.*, about 2·6 per cent. of the total locomotive weight.

Auxiliaries

A hot cathode rectifier is installed in one locomotive-half to charge the storage battery and to furnish current for the control and lighting circuits. The storage battery is of a 100 amp.hr. capacity. Two rectifier bulbs are provided, one of these serving always as a spare. There is no voltage regulator. Two double-stage air-cooled rotary compressors supply the necessary air for the air-brakes and all pneumatically operated apparatus. The driving motors of these compressors are of the single-phase series commutator type. When starting the compressor groups, the motors are connected directly to the full tension of 220 volts.

A small compressor of about 3·5 cu. ft. per min. operated

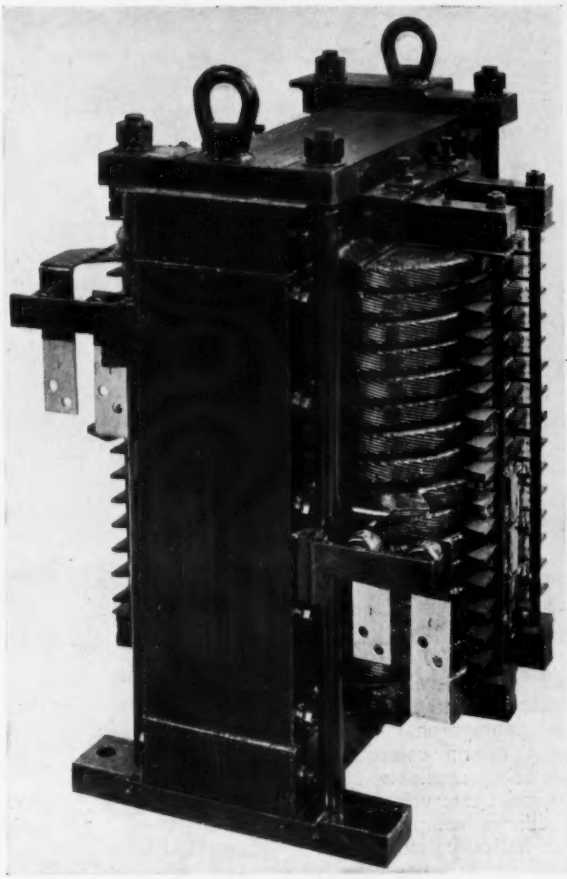
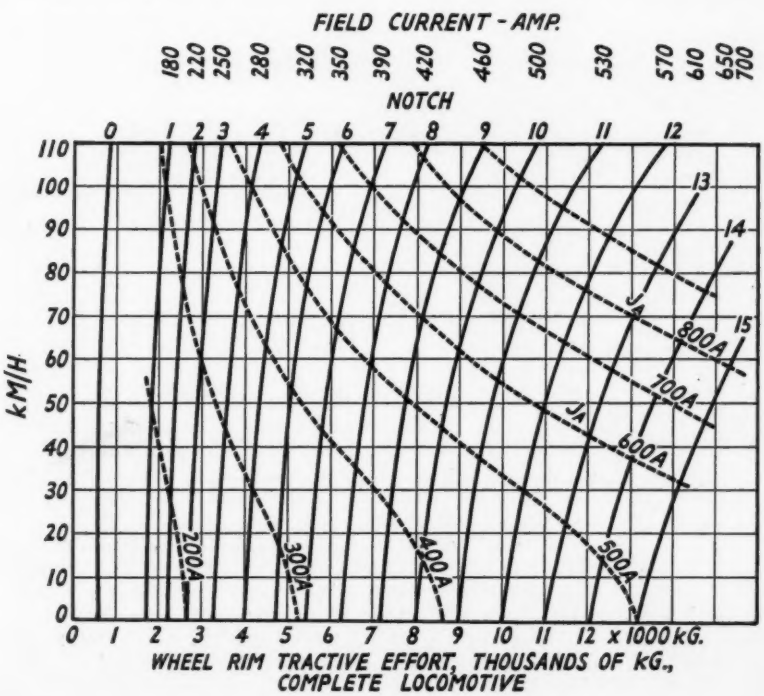


Fig. 16.—One of the four induction coils for the electric regenerative braking system



Curves 1-15 show the braking force at various speeds for braking notches 1-15.
Curve 0 shows the friction losses in the motor and gear drive.
Curves 200A-800A are the connecting lines for points of similar armature current from 200 to 800 amp.

	Normal outputs		
	45 min. rating	15 min. rating	Max. rating
Speed, km.p.h.	65	65-0	—
Armature current, amp. ..	550	700-450	900
Field current, amp.	430	550-600	700
Braking force at wheel rims, kg. (complete locomotive)	7,200	11,000	15,000
Resultant current, amp. ..	900	1,200	—

Fig. 17.—Characteristic curves of electric regenerative braking as fitted to the new Gotthard locomotive

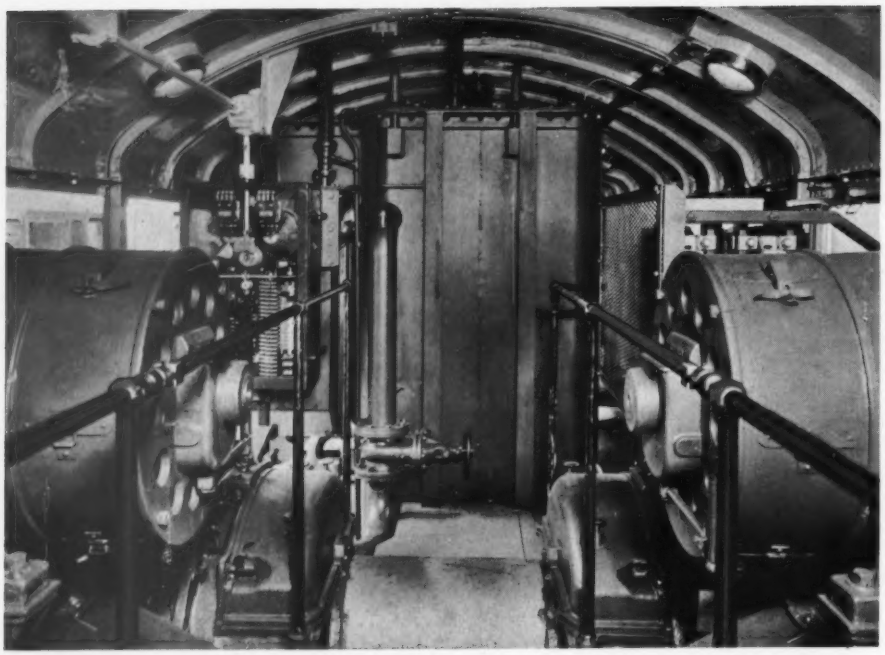


Fig. 18 (*left*).—*Interior of equipment room, showing at each side a traction motor surmounted by a motor-blower group*

Fig. 19 (*below*).—*The light-weight pantograph as fitted to the inner end of each half of the new* 12,000-*h.p. single-phase electric locomotive*

from the 36-volt storage battery is used for raising the pantographs in the event of no compressed air being available from the main reservoirs. This auxiliary compressor is automatically started as soon as the pantograph control switch in the driver's cab is put to the "pantograph raised" position. When the pantographs have touched the overhead wire, the main compressor groups are started up, and as soon as the main reservoir pressure has reached about 50 lb. per sq. in. the auxiliary compressor is cut out. For use in special cases a manual air pump is provided, and permits the pantograph to be raised even if no compressed air is available, or if no battery current should be available for the small auxiliary compressor. In common with all Swiss Federal Railways locomotives, the new machine is fitted with train-heating equipment in which the heating line can be supplied either with 800- or 1,000-volts single-phase current. The heating output of about 450 kVA is furnished by the transformer of one locomotive-half.

At each driving position are two voltmeters to check the tension of the current in the traction motors and the position of the tap-changers in the two locomotive units. These voltmeters can be connected to a certain tap on the main transformers and calibrated to indicate the voltage in the overhead contact wire any time the master-controller is brought to the zero position. In eacn driving position there are also two ammeters for the traction motor current; an ammeter for the high-tension current; a wheel-slip indicator; and an ammeter and a voltmeter for the battery. The locomotive is equipped with dead-man apparatus of the Swiss Federal Railways' standard pattern, and is also provided with Signum automatic train control, which is now being applied to all the Federal Railways' main-line locomotives. The cable installation has been carefully studied, with the result that practically no electrical conductors are visible, all cables having been neatly tucked away in the lower part of the side walls, where they are easily accessible.

Electric Railway Traction

Micheline Electric Performance

THE 32-wheeled 125-ft. Micheline pneumatic-tyred motor-coach for low voltage d.c. traction, which has been operating on the Paris suburban lines out of the Gare St. Lazare, has put up some outstanding performances. Although the top speed has been no more than 77 m.p.h., a speed of 69½ m.p.h. has been maintained up a gradient of 1 in 220, and 57¼ m.p.h. attained on the 1 in 28 gradient between Pecq and St. Germain. Numerous observations showed that from a start on this 1 in 28 grade a speed of 50 m.p.h. could be attained in 660 yd. and in a time of less than 40 sec. The normal braking force gives a stop from 50 m.p.h. in about 175 yd., but a stop from 64½ m.p.h. has been made in 153 yd., and in a time of 9·6 sec. Deceleration rates of 13 ft. per sec. per sec. have been attained during emergency brake applications. Compared with the ordinary multiple-unit trains the Micheline has shown current economies up to 30 per cent. on outer suburban stopping trains, but compared with fast trains over the same route the saving is only 10 or 11 per cent. This motor-coach, which weighs 32 tons tare and has a maximum seating plus standing capacity of about 250, has a total one-hour traction motor output of 775 h.p., and a 28-notch control. In the efforts made to reduce weight the cables have been made of aluminium and the cable ducts of the same material; the resistances are of stainless steel. The two traction motors are mounted on the underframe and weigh 2,020 lb. each, and the complete electrical equipment scales only 7·1 tons. This Micheline motor-coach was illustrated and briefly described in the issue of the *Electric Railway Traction Supplement* for October 14, 1938.

Electrification and Unemployment

THAT nearly all improvements which offer a reduction in operating expenses have to face the charge of causing unemployment was emphasised by Mr. J. H. Cansdale in his address entitled "The Case for Railway Electrification," an abstract of which is given elsewhere in this issue. It is a peculiar reflection on modern thought that the chief object of industry should be regarded as the provision of work, and it is to the tacit and general acceptance of this perversion that the employment of vast numbers of men all over the world on manufacturing instruments of death and destruction must ultimately be attributed. We use the word "perversion" deliberately, for it is the natural desire of the individual to achieve "leisure" by completing his necessary "work" with the least possible effort and in the shortest time. If, then, leisure rather than work is the true aim of the individual, it must also be the true aim of the people as a whole, who are simply the integration of the individual. This leads to the observation that the all too frequent misuse of the terms "work" and "leisure" contributes to the perversion of the object of existence. "Work" is the expenditure of energy, and whether this is done pleasantly or unpleasantly to the individual makes no difference to the necessity for work in order to exist. Every normal person must work, or expend energy, every day, the alternative being death. And "leisure," far from being synonymous with death, means the opportunity to expend energy, or "work," as one chooses. Every progressive device or process evolved has aimed at reducing human labour, and the absurdity of assuming, in the face of this obvious fact, that the object of industry is the provision of work, may be emphasised by considering what ought to be done if it were so. As soon as the devising of machinery and improved processes tended to reduce the amount of labour necessary to achieve a given quantity of production, either some of the machines should be deliberately smashed, or processes should be made more elaborate. In the case, for example, of the electrification of a railway, in order that its real economy should not throw men out of work, it should change from one system to another every few miles, beginning, say, as three-phase, continuing as direct current, going on as single-phase, and so forth. Then it should be wrecked, and rebuilt as often as might be necessary.

Electric Traction in South Africa

ACCORDING to the report of the South African Electricity Supply Commission for the year 1938, the South African Railways have 590 route miles electrified, the equivalent track mileage being 1,217. Although this is only 4½ per cent. of the mileage of the whole system, more than 25 per cent. of the entire traffic is handled by electric traction. In addition to the completion of conversion work in the Rand area, except for certain freight-yards, the Durban local line from Booth to Wests (7 miles), and the 2½-mile branch from Pinelands to Langa, on the Capetown suburban system, were turned over to electric traction during the year, and electrification of the old Natal main line between Rossburgh and Hillcrest, 23 miles, is proceeding. The consumption of electricity for traction rose from 235,961,538 kWh in 1937 to 308,884,273 kWh in 1938, this increase of 31 per cent. being due principally to the gradual extension of the Rand electrified system, the operation of which required 63,473,297 kWh, an increase of 52,587,004 kWh compared with the preceding year when only small portions of the line were electrified. The Natal electrified system, comprising about 413 route (698 track) miles consumed 193,515,650 kWh, an increase of 10·7 per cent. over the 1937 figure, and all this energy was obtained from Colenso power station, which was built in 1924 primarily to feed the Pietermaritzburg—Glencoe electrified line, and now has an installed capacity of 60,000 kW. Railway traction takes 76 per cent. of the yearly energy generated at Colenso. The Capetown suburban lines accounted for 51,895,326 kWh, or 15½ per cent. of the production of the Salt River generating station. The total traction consumption of 308,884,273 kWh represented 10·35 per cent. of the energy generated by the stations of the Electricity Supply Commission in the year 1938; 78 per cent. of the energy generated was taken up by the mining industry.

XUM

HEAVY ELECTRIC SHUNTING LOCOMOTIVES

90-ton French locomotives operating in Juvisy and Vierzon hump yards, marshalling and breaking up 2,000-ton trains at a current consumption of 56-watt-hr. per ton-mile

LAST year two big 12-wheeled electric locomotives were introduced by the French National Railways with the specific object of improving upon the performance of the standard double-bogie 1,500-volt d.c. locomotives in arduous hump yard work. Ordered by the ex-P.O.-Midi Railway before the fusion of the French railways into one big system, these new locomotives embody an unusual system of control which has no resistances, and thus eliminates the problem of the overheating of resistance elements during long spells of high tractive effort low-speed working.

Although the locomotives are of the double-bogie type, only two motors are fitted to each bogie, and the six wheels are coupled by rods which, as the bogies have outside frames, are connected to flycranks. Of the total working order weight of 90·4 *tonnes* the electrical equipment accounts for only 20·6 *tonnes*. The 55-in. wheels are spread over a bogie wheelbase of 13 ft., and the total locomotive wheelbase is 40 ft. 3 in. Actually a top speed of 30 m.p.h. can be attained, but in yard service the speed rarely exceeds 7½ to 8 m.p.h. Up the bottom part of the hump the speed is 6 to 8 m.p.h., and over the top 1 to 2 m.p.h. The main side members of the bogie frames are 24-mm. plates. Each bogie is supported on a three-point suspension system in which the underhung laminated springs of the inner pair of wheels are connected by a cross-equaliser, and the middle and outer springs on each side by an ordinary compensating beam. Automatic Westinghouse air brakes are fitted and apply two blocks on each wheel. There is also a regenerative braking system but this is not automatic. The centre pair of wheels on each bogie have thin flanges in order to assist the passage of the locomotive round curves.

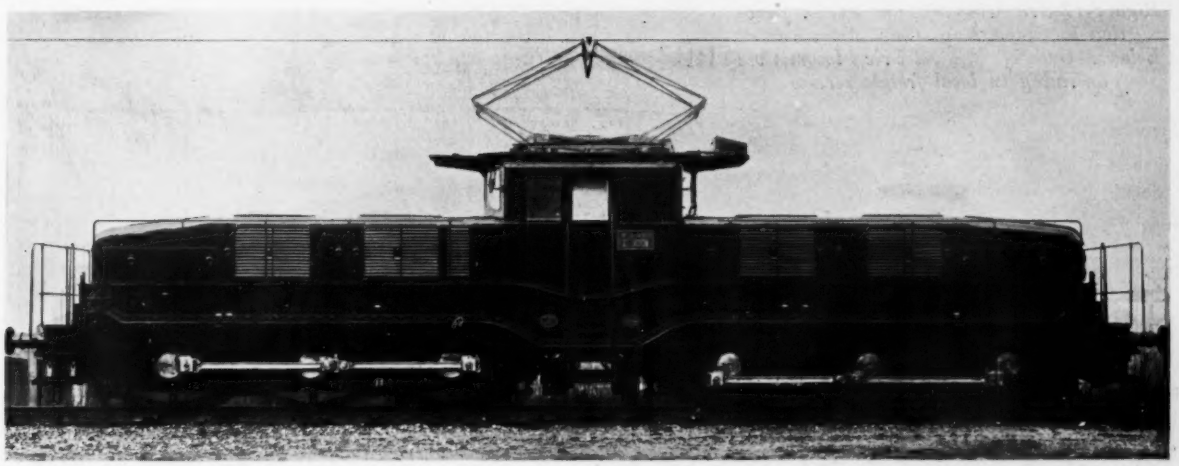
Electrical Equipment

Instead of line current being fed directly to the motors, it is passed first to a motor-generator group, which has field windings variable over a wide range. This motor-generator group comprises (*a*) a compound-wound motor which drives a generator (*b*) with an anti-compound winding; this generator feeds the armatures of the four traction motors, which are connected permanently in series, and the generator voltage may be regulated by means of an excitation rheostat; (*c*) an auxiliary generator for excitation which feeds the field windings of the four traction motors; the voltage of this auxiliary generator is regulated by an excitation rheostat; (*d*) a second auxiliary exciting generator which excites the field windings of motor (*a*) of the main generator (*b*), and of the auxiliary generator (*c*). The weight of this four-machine group is 5·8 *tonnes*, or 28 per cent. of the electrical equipment weight.

The contactors of the rheostats are operated simultaneously by the controller handle, which works through a servo motor and not directly. The positions of these contactors correspond on one hand to the voltage delivered by the main generator and fed to the motor armature, and to the intensity of the current fed by the auxiliary generator (*c*) to the field windings of the motors. The combination of these gives a definite locomotive speed. By this means the speed of the locomotive is maintained almost constant, but the current absorbed by the traction motors varies according to the profile of the line and to the load. By a diminution of the excitation of the main generator (*b*) the excitation of the traction motors is increased, which results in the decrease of the speed of the locomotive.

In the main 1,500-volt circuit from the pantograph there is a main circuit-breaker set for a rupturing current of 800 amp; an electro-pneumatic contactor set at 450 amp. 1,500 volts; and the motor of the main generator set. This last-named motor has an output at the continuous rating of 400 kW and a one-hour rating of 525 kW at a normal tension of 1,350 volts. In the traction motor circuit is first the generator (*b*) of the motor-generator group; its current is 300 amp. on the continuous rating and 385 amp. on the one-hour rating, under a voltage varying from zero to 1,500. The four traction motors drive the wheels through twin gears (one on each side of the motor, and with the gear wheel fixed to the wheel centre), with a ratio of 14 : 100 and have forced ventilation. The air required by each motor is furnished by a motor-blower group delivering 40 cu. m. a minute at a pressure of 45 mm. of water. The motors are supplied with current direct by the auxiliary generator (*d*) at a tension of 80 to 100 volts. The main traction motor current is 300 amp. on the continuous rating and 385 amp. on the one-hour rating. An

The interior of the central driving cab. The roof structure is strong enough to support the weight of the pantograph



90-ton locomotive for hump yards electrified on the 1,500-*volt d.c. system, French National Railways*

electro-pneumatic contactor, of the same type as that used in the 1,500-volt main circuit, is inserted to open and close the traction motor circuit, and two isolating switches are fitted to enable the two motors on either bogie to be cut out.

The 1,500-volt auxiliary circuits comprise the air compressor and the heating of the cab, which are supplied through an electro-magnetic contactor rated at 10 amp. 1,500 volts. The compressor is operated by a series motor of 16 h.p.; its capacity is 1,300 litres a minute at a pressure of 110 lb. per sq. in. All the low-tension circuits, such as the control and lighting, are fed at 72 volts by a cadmium-nickel battery comprising 48 cells of 72 amp.hr. capacity. The charging of this battery is normally carried out by the second auxiliary exciting generator (*d*).

THE MELBOURNE ELECTRIFIED LINES

The largest electrified system in Australasia has now been in operation for 20 *years and has carried a total of nearly* 3,000 *million passengers*

ON May 28 last occurred the 20th anniversary of the opening of the Melbourne electrified suburban system of the Victorian Government Railways. Conversion work actually began in 1913 but the war delayed operations, and it was not until 1919 that the first electric train ran—between Essendon and Sandringham. Most of the conversion work was finished by 1923, but small extensions were made up to 1930. Direct current at a tension of 1,500 volts is used, and the track gauge is 5 ft. 3 in.

As now existing, the electrified system covers 173 route miles, equivalent to 437½ track miles including sidings. Power is derived from Newport steam generating station, which is now being greatly extended at an estimated cost of £1,000,000. At the moment, its yearly coal consumption is about 150,000 tons. Almost 130,000,000 kWh for railway traction purposes are supplied each year; about 16,000,000 for railway workshops, signalling, stations, yards, and for tramways; and about 10,000,000 units are sold to industrial users.

Supply and Distribution

Energy is taken from Newport by means of 141 miles of underground cables to the substations in the inner suburban area, and by 152 miles of overhead cables, carried on extensions of the catenary structures, on the outer suburban sections. In each case the tension is 20 kV. There are 21 substations, of which 12 are automatic in operation and need no staff. The largest substation is at Jolimont, near the heart of the system; it has four B.T.H. 4,500 kW rotary converter sets which have an aggregate one-minute capacity of 36,000 kW, that is, an overload of 100 per cent. Automatic operation is applied to both rotary-converter and rectifier substations.

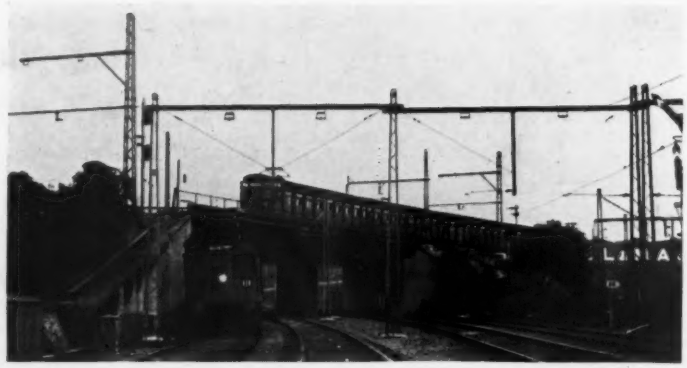
Above the main suburban tracks is an 0·25 sq. in. hand-drawn grooved copper contact wire supported by flexible droppers at 15-ft. intervals from a stranded copper catenary cable of 0·25 sq. in. c.s.a. There are no feeders for the contact wire other than the catenary. The contact wire is tensioned by weights of about 2,500 lb. every 3,000 ft. or so, but experiments have been made with a spring-tensioning system. The normal height of the contact wire is 16 ft. 6 in., with a minimum of 18 ft. over level crossings and 14 ft. 6 in. under bridges.

Rolling Stock and Mileage

The motive power and rolling stock comprises a dozen double-bogie electric locomotives and 856 motor-coaches and trailers. The passenger stock is made up into trains of two to eight cars according to traffic requirements. Each motor-coach is equipped with two motors averaging 140 h.p. each, and weighs 47-48 tons tare. The locomotives are used for shunting in the Flinders Street area, and for freight trains between Melbourne and the termini at St. Kilda, Sandringham, Dandenong, Frankston, Lilydale, Upper Ferntree Gully, Eastmalvern, Kew, and Hurstbridge. The stock includes five motor parcels vans.

Electric train mileage averages 7,500,000 a year, and approximately 130,000,000 passengers a year are carried. The number of passengers increased from 103,688,000 in 1920, in the early stages of electrification, to 160,154,499

Right : Electric train on the flyover junction at Spion Kop, near Melbourne
Below : One of the electric locomotives operating in local freight service

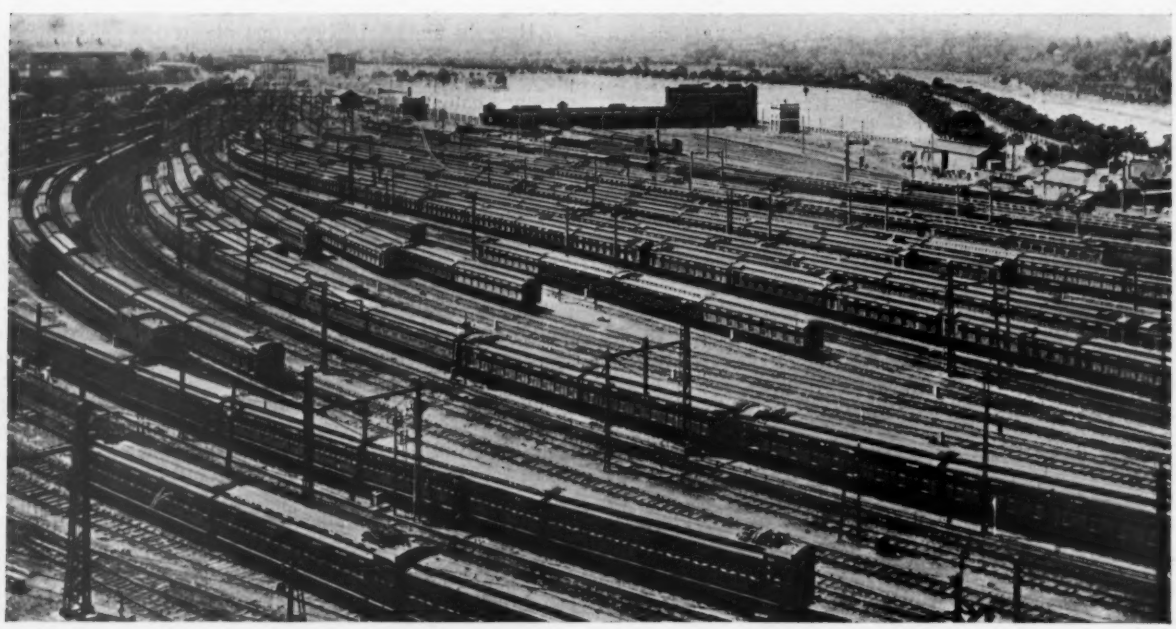


in the fiscal year 1926-27. Increasing competition and bad trade caused a drop to 120,848,507 in 1931, but last year the total was 132,035,095. One of the greatest capacity tests was on the Melbourne centenary celebration day, October 18, 1934. During that 24-hr. period 1,092,350 passenger journeys were made on the electrified lines, and 500,000 persons passed through the barriers at Flinders Street station. A total of 2,562 trains arrived at and departed from Flinders Street and Princes Bridge stations, this number being an increase of 21 per cent. over the normal. For a two-hour period trains were being signalled at the rate of one every 36 sec. at the west end of Flinders Street. A recent count of passengers using Flinders Street station on an ordinary day showed a total of 282,426, and the number of trains is now 2,170.

Taking the electric services *in toto*, the acceleration is about 31 per cent. greater than by steam traction and the frequency of service is 35 per cent. greater. Essendon, five miles from the city, is now reached in 5 min. less than in steam days ; Sandringham, eleven miles distant, in 11 min. less ; Ringwood, 15½ miles out, in 23 min. less ; and Mordialloc, 16½ miles out, in 15 min. less. The longest electric train journey possible is from Frankston to Lilydale, 50 miles. During peak periods a total of 105 seven-car trains is in service, and during the three days of the tramway strike in 1934, a total of 118 seven-car sets was in traffic at the rush hours.

Automatic power signalling has been extended and improved since the introduction of electric traction, and is now in use over most of the busy sections. Trip-gear, which automatically applies the Westinghouse brakes if a train passes a signal at danger, is installed throughout the power signalling area, and all electric trains are fitted with the necessary apparatus.

A sum of more than £6,500,000 has already been expended on the electrification, this total including £1,500,000 for the construction of Newport power station, but not the cost of the present extension, nor of the supervisory control of the power supply and distribution system now being installed. Other recent developments include improved lighting in the trains, loud speakers at Flinders Street and Princes Bridge, repainting of the passenger stock, a traffic control system, and heavier rails.



Victorian Government Railways suburban electric stock in the sidings at Melbourne

THE MAINTENANCE OF ELECTRIC LOCOMOTIVES

A correspondent summarises the careful supervision and new methods of repair which have led to appreciable reductions in upkeep costs of single-phase electrical equipment on the Reichsbahn

EXPERIENCE on the German State Railway has shown that reductions in maintenance charges for rolling stock are closely linked up with strict co-operation between the departments responsible for ordering new stock and the maintenance and repair shops. Such collaboration helps to establish standardisation of the different parts of a locomotive, and in the retention of only those which give entire satisfaction or which can be modified for future use. Prosecution of such a scheme has resulted in the reduction of the numbers of types of electric locomotive from 30 to half-a-dozen within a few years, and these six types have various features in common, such as traction motors, auxiliary motors, contactors, and control apparatus. Standardisation has produced a decided drop in upkeep costs in all workshops and depots.

Apart from measures taken in the workshops, this reduction in upkeep charges must also be attributed to two important modifications, viz., the substitution of individual axle drive for the old rod-and-jackshaft type, and the substitution of the old system of control on the secondary side of the transformer by a new method allowing progression direct from one notch to the next.

Increased Mileage between Repairs

Although at first sight the prices of general repairs appear to be rising, it must be remembered that the running time between repairs has increased in even higher proportion, indicating that the efficiency of locomotive running rises almost *pro rata* with falling repair costs per mile. For the electric locomotives of Series E.52 (an old type with rod drive) the cost of a general overhaul has risen 33 per cent. but the mileage between repairs has increased by 55 per cent. Heavy overhaul charges for locomotives of Series E.44 (modern double-bogie type) have risen by 23 per cent., but the mileage between overhauls has increased by 44 per cent. Finally, for locomotives of Series E.75 (an obsolete type with rod drive) the heavy repair costs have gone up by 15 per cent. and the mileage between heavy repairs by 17 per cent.

In 1922 the Reichsbahn introduced a new system of indexing and book-keeping, enabling each electric locomotive to be marked up according to its characteristics, dates of repairs, and so on, divided into four headings, as follow:

1. Locomotive assembly.
2. Fixed parts of the traction motors.
3. Movable parts of the traction motors.
4. Transformer.

On these cards are recorded observations made during inspections, such as mileage run and necessary repairs carried out, and from these details it is possible to determine in each locomotive series those parts whose upkeep is unduly heavy, or which are liable to too frequent breakdown, so that they may be eliminated from future designs.

Other important information is also recorded concerning such matters as the repair of motor windings, which are not usually affected except by accidental damage, or after an interval of time covering several inspection visits. Experience shows that these jobs, known as " internal," taken in relation to normal revision, can cause very heavy extra charges, which may be reduced by certain repair methods.

With regard to traction motors, the problem is particularly delicate for new armature windings, which are prone to electrical and mechanical fatigues. This problem rests primarily on the type of insulation. The choice lies between mica and bands of mica-silk. Mica is superior to mica-silk in many ways, chiefly by reason of its higher mechanical strength and its lesser sensitivity to the action of dust, particularly brake-shoe dust. But it has been found that the use of mica is more liable to give trouble, and is more costly than the use of mica silk; therefore a large number of motors supplied to the German Railways are insulated by bands of this latter material. Since the adoption of this material, the value of impregnation has been considered debatable except for the heads of coils, for which flexible micanite is sometimes used. But all parts of the armature where dust might accumulate are safeguarded by a special paste of asbestos base.

If any damage occurs to a winding ten years old or more, it has been found preferable to fit an entirely new unit rather than to try and patch up the old. All work carried out on windings requires absolute cleanliness, and during interruptions the workmen must cover the parts under repair with pieces of linen. The skimming up of the commutators is done almost exclusively by means of diamond-pointed tools. The average duration of a commutator on the German railways is generally much higher than the average period allowed for the depreciation of the locomotive itself.

In the Bavarian section of the Reichsbahn, where electric locomotives maintain particularly heavy services, the increase in speeds and loads has resulted in a number of stator and armature breakdowns. The Munich electric locomotive repair shops have, by a change in methods for stators and armatures, simplified and lowered the costs of such repairs. Since the introduction of the new methods in 1936, the economies effected approximate to 90 per cent. for stator repairs and about 80 per cent. for armature repairs, together equivalent to an average of RM. 5,000 per motor.

PARIS METRO EXTENSION.—Line No. 10, from Auteuil to Jussieu was prolonged in July from Jussieu to the Austerlitz main line station of the ex-P.O.-Midi Railway.

SOVIET CONVERSION.—Electrification work is now being carried out on the 7-mile Mashtagi—Buzovny section of the Baku electric railway, and when this is completed conversion will be extended to the Surahani—Kala section, 11 miles long, the last remaining steam portion of the loop railway round the Apsheron peninsula.

A TWO-POWER MOTOR-COACH.—The French National Railways have introduced in the Bordeaux area a motor-coach which can work either directly off the 1,500-volt d.c. overhead contact wire, or on non-electrified lines through a diesel engine and generator. It is being used at the moment between Bordeaux and Périgueux, which route is electrified only between Bordeaux and Coutras, a distance of 32 miles.

XUM

The Economics of Railway Electrification

Abstract of an address given before the E.P.E.A. Manchester Technical Group and before the Birmingham Electric Club by Mr. J. H. Cansdale, A.M.I.E.E., of the British Thomson-Houston Co. Ltd.

THERE is some difference of opinion as to the advantages to be gained by the electrification of existing steam railways. There is always a natural reluctance to make any change from what has been established, and to-day this attitude is not infrequently displayed towards railway electrification by supporters of steam traction.

In order to justify electrification it must be shown that there will be a reasonable return on the additional capital expenditure which is involved in changing over from steam. Electrification offers many advantages, but it by no means follows that in every case it is economically justified. The various factors must be given full consideration and, on account of local conditions, widely different reasons may finally influence the decision to electrify.

The lack of coal resources not only results in higher costs, but renders a country dependent upon outside supplies. To-day, particularly, this is a dangerous position to be in and every country is seeking to become as self-supporting as possible. This largely accounts for the extensive electrification work which has been done in France, Italy, Sweden, and Switzerland. Owing to the heavy capital charges on hydro-electric stations the actual cost of power is seldom less than with steam stations which have cheap coal supplies available, so that the advantage lies primarily in the availability, and not in the cost of hydro-electric power.

Grades and Tunnels

For severe grades the advantages of electric traction are great, especially where provision is made for regeneration. There are many outstanding examples of this all over the world. In America, the Chicago, Milwaukee, St. Paul & Pacific Railroad has 660 miles of electrified route on its Rocky Mountain divisions and crosses five ranges with grades averaging 1 in 50. The Virginian Railway operates a very heavy coal traffic in mountainous country over a distance of 134 miles. Originally, three large steam locomotives were required to take trains of 6,000 tons over the worst grades. With electric operation a single locomotive takes the same load, with assistance in one grade only, over the distance in about half the time. Regenerative braking effects a considerable saving both of power and of brake shoe wear, and much higher speeds are possible on down grades as there is not the limit on speed imposed by mechanical braking to prevent overheating of brake shoes and wheels. Other examples of successful electrification schemes with these special features are the South African Railways, which handle heavy mineral trains over long mountain grades, and the Great Indian Peninsula Railway which has 182 miles electrified with a ruling grade of 1 in 37.

The presence of smoke in tunnels constitutes a considerable hazard quite apart from the resulting damage and corrosion, and elaborate ventilating plant has to be installed in an endeavour to keep the tunnel clear of smoke. In some cases in the U.S.A. it is now made compulsory for railways to electrify all lines coming into a city. Since the New York Central was changed from steam to electric operation the terminal station in New York has been entirely built over and the valuable site is now being used to the best advantage.

The limit of track capacity with steam operation is frequently reached, especially with suburban lines. To add further tracks in such cases is usually impossible and electrification offers the only solution. The present intensive services on many lines have been made possible only by electrification, which eliminates terminal movements due to locomotive switching and, by better acceleration, permits a higher schedule speed to be maintained. For such suburban services the multiple-unit train is ideal, as the train make-up can be altered quickly to suit different traffic conditions at various parts of the day. The advantage of this type of train is that it can be increased in length to accommodate a greater number of passengers without any decrease in acceleration as would be the case if steam locomotives were used. The limit of track capacity has been reached in some cases with heavy goods traffic and this was another reason for electrification on the South African Railways. The higher speeds and heavier trains possible with electric traction have almost doubled the track capacity.

Power and Running Costs

In countries where coal has to be imported, electric operation can show considerable saving, especially where water power is available. In the case of the electrified section of the Mexican Railway, where, with steam operation, oil fuel was used, there was a saving of 38 per cent. on the power bill. A factor which needs to be considered is the age and efficiency of the steam locomotives which are being superseded. It is not unusual to find that the average age of steam locomotives in use on a railway is about 20 years. The last 20 years have seen a marked improvement in locomotive efficiency and this accounts for a wide divergence of figures when comparing power costs for steam and electric operation. For instance, during the period between 1910 and 1920, a figure of 7 lb. of coal on a steam locomotive was taken as equivalent to 1 unit of energy supplied to an electric train, whereas 4·5 lb. of coal is the equivalent on a modern locomotive. It is interesting to compare this with 1·5 lb. of coal per unit which is an average figure for the modern power station. Allowing for a transmission and conversion efficiency of 80 per cent, from power station to train, the ratio of coal consumption for steam and electric trains is 2·4 : 1.

Taking the published figures for the Southern Railway, which is the only railway in this country with an electric train mileage comparable with the steam train mileage, it will be found that in 1937 steam train fuel and water costs per train-mile were 8·67d. as compared to 7·44d. for the electric train-mile. The G.W.R. shows the lowest steam train cost with 6·67d. per train-mile and it seems that for this country, with cheap coal available, the power costs are likely to be, if anything, slightly heavier with electric operation.

The more efficient operation of electric trains with increased schedule speeds, together with reduced time

spent in preparation and cleaning, enables a considerable reduction to be effected in wages costs per train-mile. In the detailed analysis of costs for the L.N.E.R. section in the Weir Report the wages cost for steam operation were estimated at £671,665 and that for electric operation at £318,464, showing a saving of 52½ per cent.

In the Southern Railway report for 1937 wages per steam train-mile are given as 11·2d. compared with 2·02d. per electric train-mile. The difference here is accentuated because the first includes all goods trains whereas the second is for passenger trains only, and those mostly on suburban services. On the L.M.S.R., which ran six million electric train-miles in 1937 as compared with 33 million on the Southern, the corresponding costs are 11·67d. and 4·21d. Assuming a saving of 6d. per mile there would be a reduction in operating expenses of £25,000 per million train-miles. This represents the principal direct economy which electrification would give.

Locomotive Maintenance Costs

The electric locomotive, although initially more expensive than the steam locomotive, is much less costly to maintain. The reduced number of moving parts, the absence of the fire and boiler and the cleaner conditions of working all make for less costly maintenance. It is difficult to obtain strictly comparable maintenance costs for steam and electric locomotives as there has been little experience of using the latter in this country. Much of the electric stock is new, whereas the steam locomotives are in many cases old and consequently require more maintenance. Inherently the electric locomotive or motor-coach requires less maintenance than the steam locomotive at any period of its life. An average cost for steam locomotive maintenance in England is 3·5d. per engine-mile. This figure should be increased in comparing with electric train-miles since shunting with steam locomotives may increase engine miles to about 30 per cent. above train-miles. The corresponding cost per electric train-mile with multiple-unit stock is about 1·7d. The actual saving should be not less than 2d. per train-mile and this represents a further £8,300 per million train-miles per annum. The Weir Report, in the two detailed sections for which estimates were made, showed a saving of about 57 per cent. on maintenance in each case, and the costs given above agree with this. In the case of railways with heavy goods traffic the better basis for comparison is the 1,000 ton-mile unit. On the Chicago Milwaukee Railroad, repair and engine house expenses were 27d. per 1,000 ton-miles with steam, but were reduced to 9·5d. after electrification, thus showing a saving of 65 per cent.

ELECTRIC TRACTION AND ACCELERATION.—Tests made on the French National Railways have shown that a 130-ton 4,000-h.p. 2–Do–2 electric locomotive can accelerate a trailing load of 395 tons on the level from rest to 27 m.p.h. in 60 sec., to 53 m.p.h. in 120 sec., to 72 m.p.h. in 180 sec., and to 81 m.p.h. in 240 sec. The 72½-ton (tare) stainless steel twin-car motor-coach sets (see issue of this Supplement for August 20, 1937) can accelerate to 67 m.p.h. in 60 sec., to 78 m.p.h. in 120 sec., to 84 m.p.h. in 180 sec., and to 88 m.p.h. in 240 sec.; a top speed of 97 m.p.h. has been attained. The single-unit non-trailer-hauling motor-coaches (see issue of this Supplement for March 31, 1939) can accelerate on the level from rest to 84 m.p.h. in 60 sec., to 95 m.p.h. in 120 sec., and to 99 m.p.h. in 180 sec.; a top speed of 106 m.p.h. has been attained, and 95-96 m.p.h. maintained for some distance.

Electric Traction in Unusual Guise

THE illustration on this page shows a four-wheeled electric locomotive pulling three barges abreast on the Canal de la Haute Deule, near Lille, in France. Electric traction has proved capable of drawing three laden barges at a faster rate than the previous horse traction could deal with one barge. Current is taken by the locomotive from an overhead contact wire supported by wooden masts located beneath the trees alongside the road. A trolley wheel is balanced on the contact wire and is pulled along through a cable connecting it to the top of the locomotive. Electric traction of a similar type is in force on a number of canals in France.

SWISS ELECTRIFICATION FIGURES.—The Swiss Federal Railways now have 2,149 route km. (1,335 miles) electrified, equivalent to 73 per cent. of the total length of the system. The electrified lines carry 87 per cent. of the train-mileage and 94 per cent. of the gross ton-miles. During 1938 the current consumption was 539 million kWh for traction, of which about 93 million kWh was produced by the Etzel hydro-electric plant opened in 1937. The Federal Railways now have 494 electric locomotives as against 178 belonging to Swiss private railways, the largest being the 12,000 h.p. locomotive for the Gotthard line described in detail in the issue of this Supplement for July 21 last.

BERLIN ELECTRIC RAILWAYS.—According to a report made by Ministerialrat Rohde, of the Reichsbahn, to the International Railway Congress Association, the electrification of the Berlin Stadt, Ring-und Vorortbahnen has enabled the maximum speeds to be increased from 28 to 34 m.p.h. on the Metro section, from 28 to 40 m.p.h. on the Ring section, and from 37 to 47 m.p.h. on the suburban section. These increased top speeds, and the quicker acceleration, have enabled the average speeds to be increased from 13·7 to 19·3 m.p.h. on the Metro, from 14·9 to 20·5 m.p.h. on the Ring, and from 18·6 to 26·7 m.p.h. on the suburban lines. The train frequency on the Metro has been increased from 24 trains an hour in each direction with steam, to 40 trains an hour in each direction with electric trains. Steam trains took 116 min. to make the complete circle of the Ringbahn, whereas the present electric trains take 75 min., a saving of 35 per cent.

NOTES AND NEWS

Canadian Proposals.—A project is being considered for the electrification of a portion of the Temiskaming & Northern Ontario Railway at a cost of over £100,000.

Greek Motor-Coaches.—The Attica Railway has ordered eight twin-car articulated electric trains, for use on the standard-gauge Athens-Kephisia line, from the Cia. Generale di Elettricita, of Milan.

German Electrified Openings.—In addition to the Nuremberg-Saalfeld section, the Stuttgart-Zuffenhausen-Leonberg and Potsdamer Vorortbhf.-Mahlow sections of the Reichsbahn were turned over to electric traction on May 15.

Italian High-Speed Run.—A high-speed test run with a triple-car Breda electric train between Bologna and Milan was made at the end of May, and the distance of 137 miles was covered in 84 min., at an average speed of 95 m.p.h.

L.M.S.R. Electric Trains.—The first new three-car train for the Liverpool-Southport electrified line is now running trial trips over that route, and may go into traffic on the Southport-Crossens section until further trains are ready. Like the original trains, the new stock is of the saloon type.

French Electrification Project.—At the official opening of the Tours-Bordeaux electrification at the end of May, Mr. Guinand, President of the French National Railways, said that plans were going ahead for the electrification of the old P.L.M. main line between Laroche and Dijon, a distance of 99 miles.

Moscow Metro Traffic.—A total of 632,000,000 passengers has been carried on the Moscow Underground system since the official opening date, May 15, 1935. During the first year of operation 77,000,000 passengers were carried and during the last 12 months the number has risen to 260,000,000.

Swedish Electrification.—According to a recent report, the electrified route mileage of the Swedish State Railways now amounts to 2,218 miles, or 47 per cent. of the entire system of the country. The electrically-hauled traffic represents 72 per cent. of the train-km., and 84 per cent. of the carriage and wagon axle-km.

New Control Switch.—A new type of cam-operated controller switch has been evolved by the Westinghouse Electric & Manufacturing Company for application to industrial and mining electric locomotives. Contact is made with a rolling motion, and any arcing must occur at the contact ends, which are not depended upon for conduction when the switch is closed. The controller handle cannot be left in a position to permit arcing.

New Belgian Electric Stock.—The Belgian National Railways have passed an order for 16 new trailers in order to make up the Brussels-Antwerp trains from four vehicles to six, and have also ordered eight further two-car electric trains, each composed of two motor-coaches, in order to work the Brussels-Antwerp stopping services, which are to be turned over to electric traction in October next. Each of these new sets will weigh 104 metric tons and will have a top speed of 120 km.p.h. (75 m.p.h.).

Paris Suburban Motor-Coaches.—The trains operating over the Sceaux line (see issue of this Supplement for November 11, 1938) are composed of two motor-coaches as a unit. Each motor-coach tares 44 *tonnes* and has 90 seats and a standing capacity of 110. There are two 1,500-volt motors per coach, with an individual one-hour rating of 250 h.p. at 800 r.p.m. (26 m.p.h.) with a nominal voltage of 1,350. With a full load of passengers, this power is sufficient to give the train an acceleration of 2·6 ft. per sec. per sec. up to 20-25 m.p.h. The top service speed is 50 m.p.h.

Siemens Traction Jubilee.—The *Siemens Zeitschrift* for June contains an article covering the developments in electric traction effected by Siemens & Halske and Siemens-Schuckertwerke A.G. in the sixty years since Werner von Siemens built his first electric tractor in 1879.

French Energy Consumption.—It is understood that the consumption of electric energy for traction purposes in France during the year 1937 was 1,134 million kWh, equivalent to about 6 per cent. of the energy generated. Since that time the consumption must have risen due to the electrification of the Tours-Bordeaux line, and the full electric operation of the Paris-Le Mans line.

Italian Motor-Coaches.—Three new types of motor-coaches, for operation singly or in multiple-unit on the 3,000-volt d.c. lines, have recently been acquired by the Italian State Railways. The first type has been constructed by Breda and the outside appearance is not unlike the Breda diesel railcars. The second type is modelled on the end vehicles of the Breda triple-car high-speed trains, and the third type is an almost square-ended vehicle built by Ansaldo, Fiat, and Savigliano. Each type is powered by four motors with a one-hour rating of 92 kW each at a speed of 46 m.p.h. ; the top speed is 130 km.p.h. (81 m.p.h.). The first series has a seating capacity of 17 first class and 23 second class ; the second seats 23 second class and 56 third class ; and the third series 88 third class.

Japanese Power Plants.—To cope with the requirements of future railway electrification schemes, the Japanese Ministry of Railways is undertaking the development of two hydro-electric stations—Senju and Yamabe—on the Shinano river. The eventual installed capacity is to be about 200,000 kW, and it is expected that 40,000 kW will be in commission early next year. The normal water flow is equal to 167 cu. m. per sec., with a maximum of 250 cu. m. A two-storey building, 375 ft. long and 85 ft. wide, is to house the mechanical equipment, the ground floor housing the water turbines and the upper floor the generators, switchgear, and other accessories. Five main generating sets are to be installed along with two smaller units for the requirements of the plant itself. The Francis-type vertical turbine units to be used will have a maximum output of 44,700 kW at 150 r.p.m. with a waterflow of 89·1 cu. m. per sec. and a maximum effective head of 58 metres. The turbine cast steel rotor wheel is to measure 12 ft. 3 in. in diameter, and will weigh 23 tons ; the main shaft is to be 29½ in. in diameter, and will be connected to the generator by a further shaft 6 ft. 6 in. long. The generators are to be rated at 31,000 kVA 11 kV 50 cycles, and will have an outside diameter of 37 ft. 9 in. and a height of 39 ft. 6 in. Set on the top of the main shaft will be two exciters. The main transformers and their switchgear are to be of the outdoor pattern. A turbo-generating set and transformer rated at 1,000 kVA 3·3 kV 50 cycles are being constructed to supply the needs of the generating station. A 140-kV transmission line, 118 miles long, is being built from the Senju hydro-electric plant to a switching station at Musashi-sakai, about 18 miles from Tokyo on the Chuo main line. Here the current is to be stepped down to 60 kV.

Electric Railway Traction

Electric Working in Holland

ACCORDING to recent statistics, the Netherlands Railways have a total of about 315 route miles of line electrified, including practically all of the most important main lines. This length represents about 15 per cent. of the whole route mileage of the State-owned railway system. Another 16 route miles are now under conversion. The first electrification was carried out in 1908 on the 6,600-volt 25-cycle single-phase principle, but since the beginning of the big electrification programme in 1927 all conversion has been on the 1,500-volt d.c. system, and the single-phase line between Rotterdam, The Hague and Scheveningen has been changed to the standard d.c. principle. In general the supply is three-phase 10,000 volts, but with variations from 5 to 50 kV, and it is converted into the contact line current in 32 mercury arc rectifier substations either remotely-controlled or automatic in operation, and with an aggregate installed capacity of 66,800 kW. The motive power and rolling stock are entirely in the form of multiple-unit trains, all the recent stock being of all-steel streamlined construction made up in units of two and three coaches, so that any desired combination can be operated. Last year the electric train mileage was approximately 7,815,000 and the current consumption about 130,000,000 kWh, or twice what it was in 1933.

Norwegian Electrification Scheme

THE administration of the Norwegian State Railways recently put forward to the Norwegian Government a scheme for the extension of electrification works to be undertaken in Norway. The lines already electrified are: Oslo—Drammen—Kongsberg—Hjuksebø—Nordagutu, Tinnoset—Notodden—Borgestad, Oslo—Lillestrøm, Voss—Granvin, and the Ofoten Railway, the continuation from Bjørnefjell to the port of Narvik of the Swedish Lapland iron-ore railway. Work is proceeding on the Flåm Valley and Oslo—Kornsjo sections, and it is expected that the latter line will be opened to traffic with the introduction of the summer timetables in 1941.

The first and probably the most important of the proposed new electrifications is the Bergen Railway. The Oslo—Bergen line is 492 km. (305 miles) and runs over mountain grades to a height of about 4,000 ft. Some doubt was expressed as to the safety of electric working during winter months, but experience on the Ofoten Railway has proved such doubts to be unfounded. The total estimated cost of conversion is Kr. 48,308,500 (£2,415,425), of which the Oslo—Hønefoss section (90 km., or 56 miles) accounts for Kr. 11,274,000 (£563,700), and the Bergen—Voss section (107 km., or 66 miles), Kr. 11,622,000 (£581,000). These calculations were made separately as it might be found advisable to electrify certain sections without extending conversion to the whole line.

Next in importance is the Nordagutu—Kristiansand line, some 220 km. (136 miles). When the Kristiansand—Stavanger section of the Sørland railway, now under construction, is opened, the Nordagutu—Kristiansand section will at first continue to be steam-operated, but to enable fast electric trains to run between Oslo and Stavanger and to avoid a double change of locomotive, it would be better to convert this portion also. The cost would be some 16 million Kr. (£800,000) at present-day prices.

Next on the list are the Vestfold, Drammen—Eidanger, and Eidanger—Borgestad lines (146 km., or 91 miles), which have now been converted from narrow-gauge to 4-ft. 8½-in. gauge. This combination is an isolated section of steam-worked track amid normal-gauge electrically operated lines. The cost of electrification will be some 11 million Kr. (£650,000), but this figure includes a suggestion for strengthening the permanent way at an estimated cost of 7 million Kr. (£350,000). This line is the only one with an already installed power supply. The other conversions will need enlarged or new electric current supplies, which most probably will be hydro-electric generating stations at various points.

Finally come the Lillestrøm—Hamar and Lillestrøm—Swedish frontier at Charlottenberg lines, whence the track is electrified throughout to Stockholm. These two lines are 220 km. (136 miles) in length, and the estimated costs are Kr. 27·5 million (£1,375,000). This rather heavy expenditure is accounted for by the necessity for installing current supply. The Storting has decided on conversion in the following order: Bergen—Voss and Nordagutu—Kristiansand, in spite of the railway administration's recommendation that the Vestfold and Eidanger—Borgestad lines should receive priority, and that the Nordagutu—Kristiansand section await its turn.

Tube Train Performance

SPEAKING to 500 employees of the British Thomson-Houston organisation at Rugby a short time ago, Mr. W. S. Graff-Baker, Chief Mechanical Engineer to the L.P.T.B., emphasised the absolute necessity of good workmanship in order to provide the high standard of reliability needed for the London tube train service. Taking a specific example of 35 trains each with five sets of equipment, Mr. Baker said that over 1,575 equipment-weeks there had been only 18 failures from all causes, equivalent to 0·01 failures per equipment-week, or one every two years. The trains on the tube sections ran approximately 70,000 miles a year each, so that if the electrical equipment accelerated the trains only once between each pair of stations, each equipment operated 140,000 times a year with stations half-a-mile apart, subject all the time to the vibration inherent in the motion of a train. Mr. Graff-Baker also dealt with the question of brake-shoe dust, which not only settled on everything below the train and built up a metallic film over insulating material, but had also caused trouble by getting into escalator motors, which were at least 100 ft. away from the tracks. Forty trains an hour were operated in one direction over a single track; the acceleration was 1·25 m.p.h.p.s., but with the new stock and the possibility of easily motoring what are now trailer cars, it would be practicable in the future to have a service acceleration of 1·65 m.p.h.p.s.

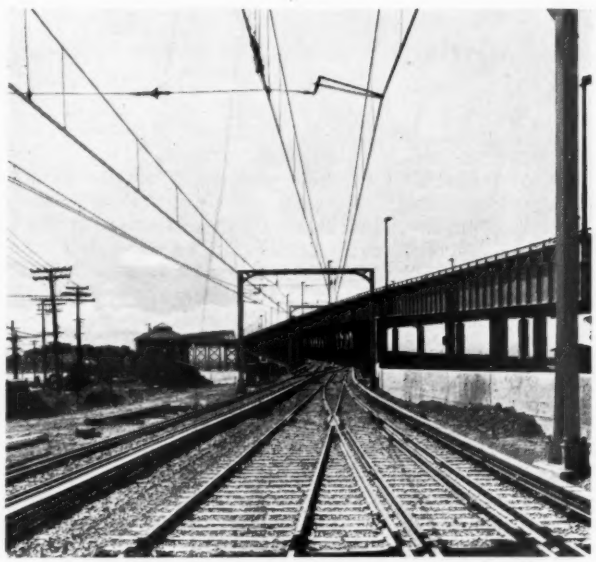
XUM

THE SAN FRANCISCO - OAKLAND CONNECTING RAILWAY

The new lines giving railway connection between San Francisco and Oakland over the Bay bridge comprise 32 track miles, electrified on two systems and fed through 20,000 kW of rectifier plant. Electrification and railway construction and alteration cost about £5,000,000

TOWARDS the end of last year the first electric train passed over the new 4-mile San Francisco—Oakland Bay bridge, and a regular service began in January of this year. Including approaches and the tunnel through Yerba Buena Island about midway across the bay, the bridge is 8¼ miles long; on the top deck is a roadway, and on the lower deck is a double line of railway and a three-lane highway for commercial road vehicles. The two railways using the bridge are the Interurban Electric Railway (a subsidiary of the Southern Pacific), which uses 1,300 volts d.c. with overhead collection; and the Key System, which uses 625 volts d.c. with a third rail. The layout of the railway portion of the bridge and its approaches, and the track arrangement at each end, are designed to cope with the transport of 50,000,000 persons a year over San Francisco bay; the present traffic is about 30,000,000. The train journey by bridge saves about 15 min. compared with the ferry-boat.

At the Oakland end the double-track line runs on to the bridge *via* a long mole, but at the Frisco end the two tracks become three immediately after leaving the bridge, and then form a loop which has six tracks through the city terminal. All these tracks are carried above street level, as may be seen from the full-page aerial view reproduced with this article. From the interlocking limits at San Francisco to Yerba Buena island the bridge is 11,400 ft. long, and from the island anchorage to the Oakland interlocking is 12,400 ft. At the Oakland end, the existing track layout of the Key System has been entirely remodelled. No provision has been made to operate through passenger trains over the bridge to San Francisco, and main-line trains on the Southern Pacific and Western Pacific Railroads terminate at the Oakland moles, and the passengers are ferried over the bay.



Easterly approach, looking from Oakland, to the Bay bridge. Mole substation is to the left of the left-hand catenary mast

Overhead contact system and conductor rails on eastbound tracks leaving the San Francisco passenger terminal of the Interurban Electric Railway and the Key System

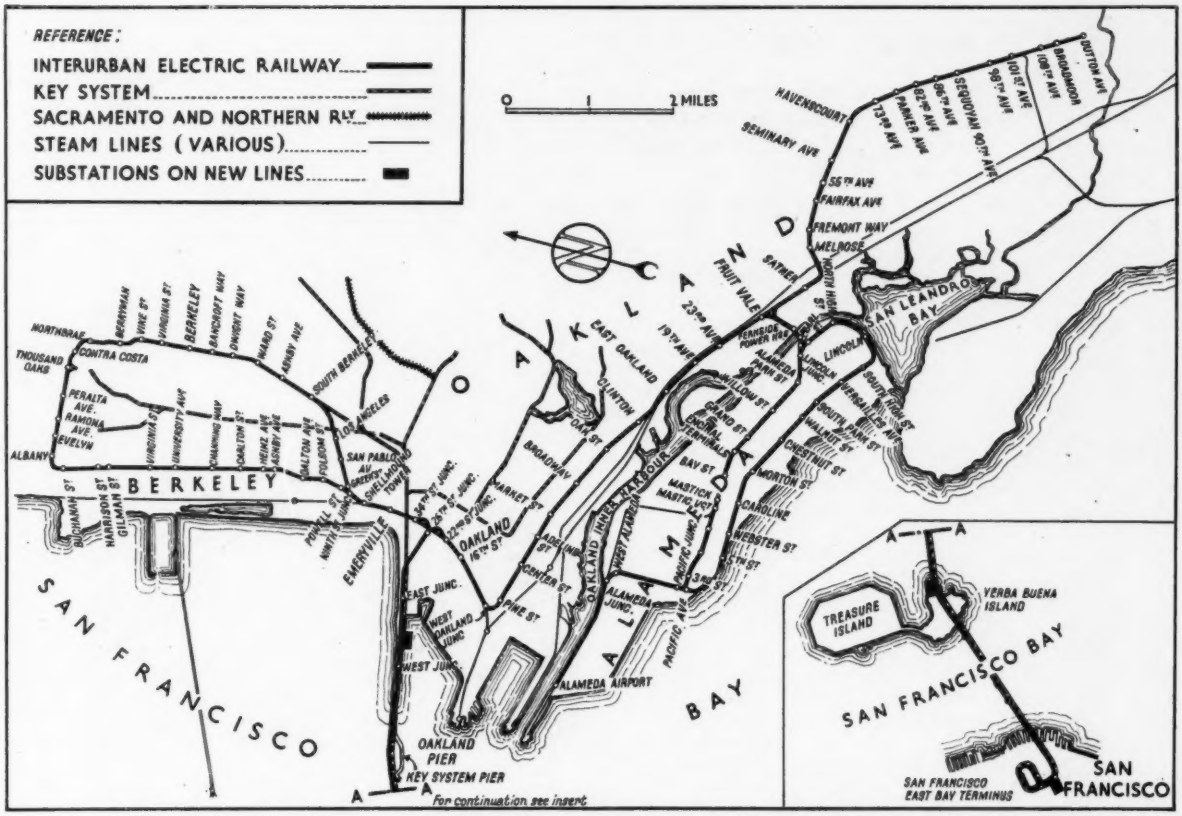
Passenger Capacity

A maximum train speed of 35 m.p.h. is permitted over the bridge, and the capacity of the trains and the characteristics of the signalling equipment enable a headway of 64 sec. to be used, although at the moment 75 sec. is the maximum peak attained, and this enables 9,000 passengers to be taken away from San Francisco terminal during the 20-min. peak from 5.0 p.m. to 5.20 p.m. On an average weekday about 40,000 interurban passengers travel in each direction by rail.

The peak formation of the Key System's trains is a seven-unit articulated set 773 ft. long and weighing 541 short tons when loaded with 868 passengers; the motor output is 3,080 on the one-hour rating. On the Interurban Railway the peak-hour train consists of six motor-coaches and four trailers with a length of 724 ft. Loaded with 1,160 passengers they weigh 571 short tons, and the traction motor output is 3,360 h.p. Operation of these trains produces maximum half-hourly loads of 4,250 kW on the San Francisco side and 3,100 kW on the Oakland side of the Interurban Railway; and 3,300 kW at San Francisco, 3,080 kW at Yerba Buena island, and 2,080 kW at Oakland on the Key System.

Power Supply

Each track on the bridge is available to h.t. or l.t. trains. Adjacent to the tracks are three substations which are fed by three-phase 12-kV current, and deliver the



Map of the San Francisco and Oakland areas showing the layout of the Interurban Electric Railway, the Key System, and the Sacramento Northern Railroad. Sacramento Northern Railroad trains have running powers into San Francisco over the Key System. The tracks between Oakland mole and San Francisco terminal are used by the trains of all three lines

appropriate d.c. to the tracks. The Interurban line is fed at the east and west ends by the Sterling and Mole substations, and the Key System, with its lower conductor rail voltage, is fed from these two and from a substation on the island approximately mid-way across the bay. At the Oakland end of the bridge the tracks of the two companies diverge, and follow existing routes, the new works being the prolongation of these Oakland, Alameda and Berkeley lines into the city of San Francisco. Previously, the lines terminated at two separate moles at Oakland.

Energy is supplied by the Pacific Gas & Electric Company from its C station located at Oakland, and at which energy is generated by steam and further power received from distant hydro-electric stations. Three feeders run from station C to the Mole substation, and these energise a 12-kV busbar which is tied to a second 12-kV busbar in an adjacent switching station, P. From P two submarine cables are led to Treasure Island, and two further submarine cables (one old and one new) running to San Francisco by way of the Army Point substation on Yerba Buena island serve the Island traction substation by means of ties between the two substations. Existing submarine cables between power station C at Oakland and a second power station W, in San Francisco, are now looped through Sterling substation, and in addition this sub can also be supplied through a tie from another steam generating station in San Francisco.

Substation Equipment

Power at the substations is taken through breakers on to a sectionalised a.c. bus, and fed through breakers to the main transformers and thence to the rectifiers. Positive d.c. is taken from the rectifier through a d.c. breaker to the d.c. bus of appropriate voltage, and from there through track breakers to the overhead contact system or conductor rail. With minor exceptions the rectifiers and transformers were supplied by the General Electric Company and the switchgear by the Westinghouse Electric & Manufacturing Company.

At Sterling substation the 12-kV feeders enter underground. The a.c. breakers are of the metal-enclosed lift-up type with a rupturing capacity of 500,000 kVA, and the switchboard is furnished as an integral part of the switchgear enclosure. The single a.c. bus is in two sections, each of which is connected to a single feeder and connected by a bus tie breaker; the third feeder can be connected to either side. From the a.c. board to the main transformers the cable is 15-kV 500,000-circ. mil. paper-insulated lead-covered, carried in conduit, and is wiped directly to the pothead on the transformer, leaving no parts exposed.

Rectifier and Transformer Connections

Sterling sub has four 2,000-2,500-kW rectifiers, two for the 625-volt lines and two for the 1,200-volt lines. 12-phase current is supplied by the transformer. The primary of the main transformer is wound delta, and each leg of the secondary carries eight windings, *viz.* four long and four short, or 24 secondary windings in all. One short and one long leg in series constitute one leg of a Y, four Ys in all yielding 12 legs with voltages displaced by 30 deg. Each of these is connected to one rectifier anode.

The San Francisco—Oakland Bay bridge looking from San Francisco. To the left side of the railway loop in the foreground is the six-track San Francisco terminal. To the left of the island in the bay is the Golden Gate international exposition. The bridge itself has a road deck on top and a road plus rail deck below. Two different d.c. voltages are used by the electric trains using the bridge and the San Francisco loop

If the neutral points were tied directly together to form the negative return, each anode would fire for 30 deg. (neglecting inductive overlap inherent in the system), the next anode taking over as its voltage rose above that of the one firing. This would mean that each secondary winding and anode would be called upon to carry full load for one-twelfth of the cycle, but by means of interphase transformers the firing of the anodes is caused to overlap. If, for example, No. 1 leg has reached the peak of its voltage wave, those windings of the interphase transformers which form part of the circuit tend to resist the change in current by supplying a counter voltage as the voltage starts decreasing. Similarly, these interphase windings tend to oppose the increasing voltage in leg No. 2, which is following the first leg with a lag of 30 deg. This action continues until the voltage of No. 5 leg exceeds that of No. 1; as there are no interphase windings in the circuit between legs 5 and 1, both being on the same Y, No. 5 anode starts firing when its voltage exceeds that of No. 1. Thus, four anodes are firing at any given time, each of the 12 through its own 120 deg., and each anode and secondary carries but a quarter of the normal current, but carries it four times as long.

The standard steel-tank rectifiers are rated at 2,000 kW 625 volts continuous for the Key System supply and 2,500 kW 1,300 volts for the Interurban lines. All rectifiers can carry 150 per cent. load for two hours, 200 per cent. load for 30 min., 300 per cent. load for 5 min., and 500-600 per cent. load momentarily. Continuous automatic voltage regulation is accomplished by means of grid control, which yields flat voltage to 150 per cent. load and an approximate 5 per cent. regulation slope beyond. Each rectifier is cooled by a closed water system. The vacuum in the tank is maintained by a Langmuir mercury condensing pump which pumps into a receiver; in turn, this receiver is discharged to atmosphere by means of a rotary pump.

The main transformer associated with each 625-volt rectifier is rated at 2,260 kVA three-phase 60 cycles, 12,300 volts delta/595 volts line to neutral, quadruple zig-zag. The three interphase transformers associated with each rectifier are enclosed in a single tank; two are rated single-phase 180 cycles 308 kVA 384/192 volts, and the third single-phase 360 cycles 224 kVA 140/70 volts. For the 1,300-volt rectifiers the main transformers are 2,780 kVA with 1,220 volts line to neutral on the secondary. The 180-cycle interphase transformers are 370 kVA 770/385 volts, and the 360-cycle interphase transformer 266 kVA 276/138 volts. The neutral terminals of both sets of interphase transformers are connected to one negative bus, which in turn is direct-connected by copper tubes with 16,000-amp. capacity to the track running rails.

Leaving San Francisco, the heavily-loaded evening peak trains travel to the bridge round a 20-deg. curve and on to a 1 in 25 grade. Therefore, the Interurban lines have a supplementary feeder 4,000 ft. east of Sterling sub, and similar supplementary capacity is provided at the Oakland end. The 625-volt Key System has an extra feeder 3,500 ft. east of Sterling. The 1,200-volt d.c. overhead catenary system comprises main and intermediate

Interior of San Francisco terminal, with six electrified tracks. Eleven ramps and 14 stairways give communication with the streets

messengers and two contact wires, with an aggregate copper cross section approximating to 1,000,000 circ. mils. On the Key System, the 150-lb. conductor rails, of low-carbon steel, have a copper equivalent of 2,730,000 circ. mils. The running rails constituting the return are properly bonded, and are equivalent to 3,500,000 circ. mils. of copper per track.

Supervisory Control

All three substations and the five sectionalising huts are controlled from the Mole substation. One pair of wires in a 50-pair telephone cable is carried to the Island sub, and another pair to Sterling. Over these two pairs of wires the system is operated by supervisory control. The operator at the Mole sub can control at Sterling the opening and closing of all 12-kV oil circuit breakers, start and stop all rectifiers, change taps on the 1,300-volt transformers, and close and lock out all d.c. feeders. In addition he receives indications of the d.c. on each rectifier, the voltage on the 12-kV bus, the voltage on the 625-volt bus, the voltage on the 1,300-volt bus, the voltage on the 220-volt house bus, the voltage on the 125-volt d.c. control circuit, the temperature above 175° F. at the substation ceiling, and the opening of the substation door.

Tap-changing on the primary side of the main transformers enables the Interurban contact lines to have a tension of 1,275 to 1,350 volts d.c. in six steps, the operation being under no load; these main transformers have manually-operated no-load tap-changers, affording four 2½ per cent. steps. Thus the operator can set the transformers for optimum operation of the trains at any time, and can thus match the speed of the Interurban trains with those of the 625-volt Key System trains.

Signalling and Train Control

In order to obtain the required headway in conjunction with the top speed of 35 m.p.h., a system of continuous cab signals with automatic braking and speed control has been installed. This arrangement requires the driver to make a service brake application as the train approaches a restrictive block, and eliminates the use of overlap. The speed governor on the train permits continuous control of the train speed, depending upon the distance to the preceding train, and over the bridge and

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its approaches there are four possible speeds, *viz.*, 11, 17, 25 and 35 m.p.h. The cab signalling and control on the trains are regulated by coded impulses superimposed on the rails ahead of a train. These impulses are picked up inductively, amplified and decoded by relays and tuned transformers to accomplish selection of the different cab signal aspects and speed controls.

When a driver of a Key System train, or of one of the Sacramento Northern trains which have running powers over the Key System bridge route, receives an audible warning that its speed is above the value governed by the state of the track ahead, he must take action to keep his speed to the defined limit. If he does not take action and the speed continues to increase, an automatic emergency application of the brakes is made, and power is cut off at about 1 m.p.h. above that one of the four possible speeds which is in force. On the Interurban trains, when the audible warning is given the power is automatically shut off, and if the driver does not place his brake handle in the full service position within 2½ sec., an emergency brake application is made automatically. Each time the aspect of the cab signal is changed to one more restrictive, the audible indication is given, and the driver has 2½ sec. to shut off the power and initiate a service brake application. If the train is running below the new speed limit no audible indication is given.

The new lines are track circuited, and a feature of the system is that the occupancy of any one track circuit establishes the location and length of the three successive speed zones to the rear. In effect, the protection moves along behind the train in jumps of 250 to 500 ft. At the San Francisco end there are two inbound and one outbound track at the bridge approach; the incoming Key System and Sacramento Northern trains are routed over the centre track and go to the three southern tracks at the terminal, whereas the incoming Interurban trains are routed *via* an outside track to the three northern tracks at the terminal.

Train Sets

There are 88 twin-car articulated train sets on the Key System, 17 motor-coaches of the Sacramento Northern, and 110 Interurban Electric motor-coaches, all fitted with train control and cab signalling equipment. Each Key System set seats 134 persons and each Interurban Electric car 116 persons. A total of 520 electric trains runs into and out of the San Francisco terminal on a normal weekday, but no freight trains are handled.

Cost

The cost of the railway works has been nearly $20,000,000, of which the three substations cost $1,500,000; alteration to railroad equipment to suit it to the bridge and the new operating conditions $5,000,000; the San Francisco terminal $3,200,000; signalling equipment $1,370,000; purchase of land, administration and initial financial charges about $7,000,000; catenaries and feeder lines $370,000; and rail bonding $32,500. The cost was borne mainly by the Reconstruction Finance Corporation, which advanced credits of about $16,000,000, of course in return for railroad bonds.

For much help in connection with the preparation of this article we have to thank Mr. Paul Lebenbaum, Electrical Engineer of the Southern Pacific Railroad.

LETTER TO THE EDITOR

Traction Motor Ratings

Wilkinsburg, U.S.A.,
August 19

TO THE EDITOR OF THE ELECTRIC TRACTION SUPPLEMENT

SIR,—In the *Electric Traction Supplement* of July 21, 1939, is a complete description of the new 10,600 h.p. (continuous) electric locomotive of the Swiss Federal Railways. It is interesting to note that this high rating is largely a result of the use of I.E.C. rules, but it is unfortunate that these rules permit two ratings instead of one.

At the Milan meeting in 1933, at which the I.E.C. rules were adopted, the writer protested very vigorously against Table 2, which gave alternate ratings. Also, at the Milan meeting it was pointed out that the temperature rises as per Table 1 of 105° C. for continuous rating with Class B insulation were very conservative. Since then the American Standards Association rules of March, 1937, have increased the allowable temperature rise from 105 to 120° C. for armatures and to 130° C. for fields. Even these rises are considered conservative, and experience demonstrates that temperature rises on modern railway motors with Class B insulation are limited by the melting point of solder and by expansion and contraction.

The hauling capacity of the new Swiss locomotive is given as 600 tons for express passenger trains at 40 m.p.h., and 750 tons for freight trains at 31 m.p.h. on grades of 2·5 to 2·63 per cent. These grades, presumably, are compensated, and require less than one hour to traverse. About 5,600 h.p. at 15 per cent. adhesion for the express trains and 5,100 h.p. at 18 per cent. adhesion for the freight locomotives would be required. It would appear that the new locomotive should readily haul 1,000-ton trains at 50 m.p.h. up the grades mentioned if developing the continuous capacity of 10,600 h.p. with 22 per cent. adhesion, and it would be of interest to know why the full capacity is not being utilised.

GERALD F. SMITH

BELGIAN VICINAUX.—Although only about 30 per cent. of the route length of the Belgian National Light Railways is operated by electric traction, the receipts from these lines amount to 69 per cent. of the total.

MORE ACCELERATION FIGURES.—Supplementing the data on actual acceleration of various French electric locomotives and motor-coaches given on p. 99 of the issue of this Supplement for August 18, the 32½-ton (tare) Red Arrow motor-coaches of the Swiss Federal Railways, with two motors aggregating 346 h.p. at 53·5 m.p.h. on the one-hour rating, have been timed up a 1 in 56 grade to accelerate from rest to 20 km.p.h. (12·4 m.p.h.) in 20 sec., to 30 km.p.h. (18·6 m.p.h.) in 27½ sec., to 40 km.p.h. (24·8 m.p.h.) in 37 sec., to 60 km.p.h. (37·3 m.p.h.) in 53½ sec., and to 88 km.p.h. (54·6 m.p.h.) in 80 sec. Along the straight level the acceleration was from rest to 20 km.p.h. (12·4 m.p.h.) in 11 sec., to 40 km.p.h. (24·8 m.p.h.) in 21½ sec., to 60 km.p.h. (37·3 m.p.h.) in 32¼ sec., to 80 km.p.h. (49·7 m.p.h.) in 44 sec., to 100 km.p.h. (62·1 m.p.h.) in 60 sec., to 120 km.p.h. (74·6 m.p.h.) in 93 sec., and to 125 km.p.h. (77·7 m.p.h.) in 109 sec. On the 1,500-volt d.c. Capetown suburban system (3 ft. 6 in. gauge) of the South African Railways, the 322-ton eight-car (two motors and six trailers) multiple-unit trains normally accelerate on the level from rest to 5 m.p.h. in 10 sec., to 10 m.p.h. in 18 sec., to 15 m.p.h. in 26½ sec., to 20 m.p.h. in 35 sec., to 25 m.p.h. in 44 sec., and to 30 m.p.h. in 58 sec.

ELECTRIFICATION IN THE URALS

Steeply-graded lines with heavy mineral traffic and main-line passenger trains are operated on high-tension d.c. system

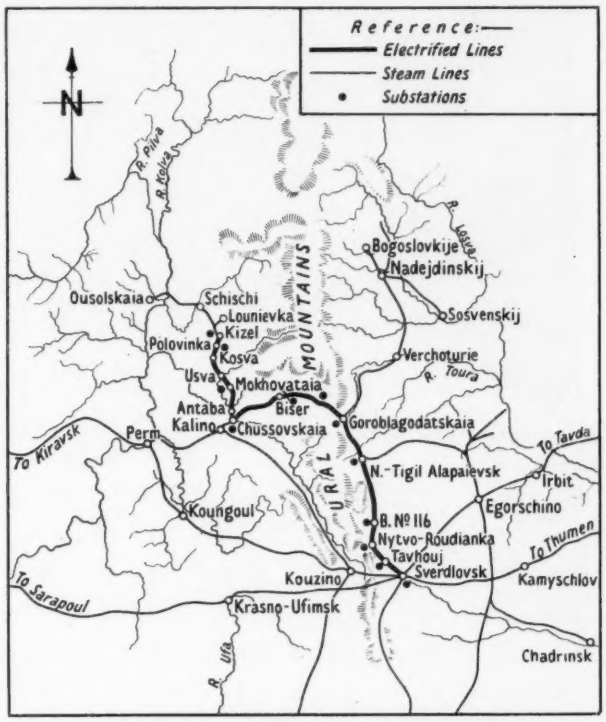
THE Kizel-Chussovskaia line forms part of the former Uralo—Gornozavodskaia railway. It was constructed by a limited company between the years 1874 and 1879 and became State property on July 1, 1887. The line was intended to convey coal from the Kizel area, and with the rapid development of this industrial region, including the inauguration under the first Five-Year Plan of the large chemical works at Berezniaki and the calcium mines at Solikamsk, traffic increased greatly, as indicated in the attached table.

	Thousand *tonnes*
1928	1,069
1930	1,200
1933	1,400
1934	Over 2,000

The construction of new factories under the Second Five-Year Plan has meant further increases in traffic, and traffic up to 8 million *tonnes* is envisaged.

The maximum capacity of the line—21 trains in each direction daily, 14 of which are freight—is almost reached. A further increase could be obtained by means of building new stops and loops, but on account of the mountainous nature of the line the work involved would not be justified by the advantages gained. With the maximum load hauled by steam traction of 730 *tonnes* from Kizel to Chussovskaia, and 550 *tonnes* in the opposite direction, the maximum traffic capacity could not exceed 3,730,300 *tonnes* annually, but electrification has enabled this maximum to be considerably increased, by reason of higher schedule speeds enabling more trains to be run, and because the greater power permits heavier trains to be hauled.

Of the total length of 112·5 km. (70 miles) of route, only 6 per cent. is on the level and more than 70 per cent. is over curves. The maximum gradient is 1·8 per cent.



Map of the electrified line between Kizel and Sverdlovsk, 240 miles, in the Ural Mountains mineral area of the U.S.S.R.

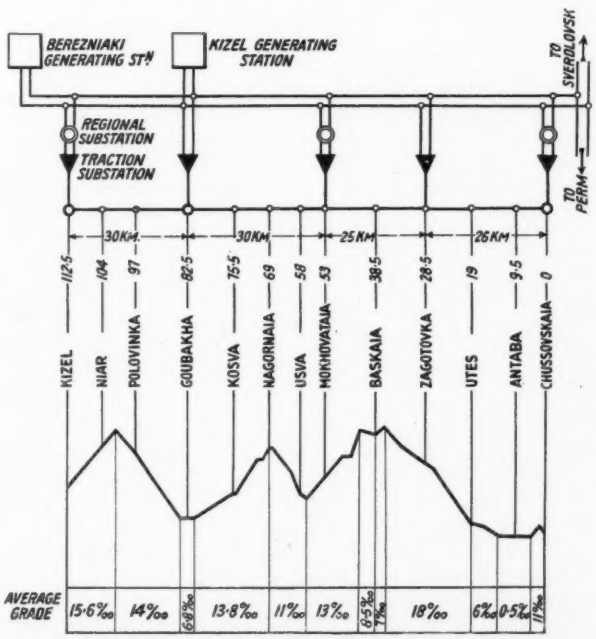
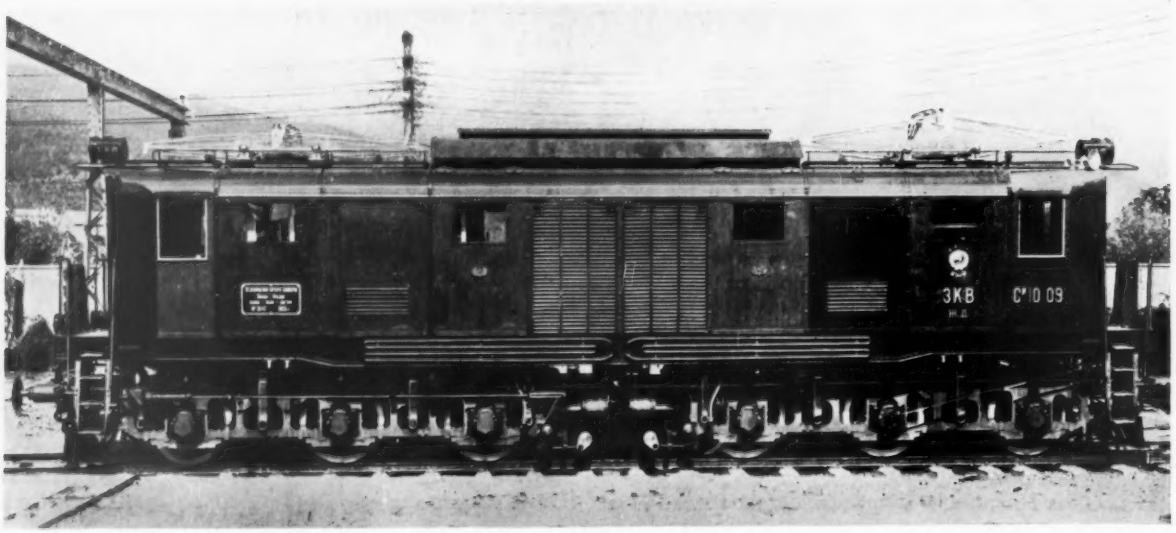


Diagram of the supply system, and profile of the electrified line, between Kizel and Chussovskaia

(1 in 56) in both directions, with curves of radii as sharp as 320 m. (1,050 ft.). Inclines of 1·5 per cent. (1 in 67) form 33 per cent. of the total distance running from Kizel to Chussovskaia, and 38 per cent. in the opposite direction. Partial electric traction at 3,000 volts d.c. began over this section at the end of 1933, and a full service during the next year, and subsequently electrification was extended over the main line from Chussovskaia to Sverdlovsk.

Overhead Structure

The catenary system is comprised simply of a steel carrier of 70 sq. mm. cross section and a single copper contact wire of 100 sq. mm. section. Provision has been made to instal easily a second copper contact wire if increased traffic should necessitate, and a double wire is used now in tunnels and over bridges. In designing and erecting the overhead system, account had to be taken of the large temperature variation—from 30° C. to −45° C. Wind speeds allowed for are up to 68 m.p.h. in conjunction with a temperature of 5° C. and 35 m.p.h. with a temperature of −5° C. On straight sections or on curves with a radius not sharper than 1,000 m. (3,280 ft.) the masts are spaced 65 m. (214 ft.) apart; on curves of 532 m. (1,750 ft.) radius, the spacing is 45 m. (148 ft.), and on 320 m. (1,050 ft.) curves the standard spacing is 38 m. (125 ft.). The copper contact wire is carried at a nominal height of 6·4 m. (21 ft.)—the standard Soviet loading gauge is just over 17 ft. high—by wooden masts; in sidings or stations having eight or more tracks, a cross-catenary system with steel masts is used. At over bridges and



An Italian-built 3,000-volt d.c. electric locomotive with an output of 3,000 h.p. at 18 m.p.h. on the one-hour rating, used for hauling mineral trains in the Urals

through tunnels the contact wire is lowered to a minimum of 5·2 m. (17 ft. 1 in.). An aluminium feeder line is carried along the whole of the electrified route. Costs of manufacturing and erecting the complete overhead system have been given as 1,314 roubles per km. with wooden masts and 2,500 roubles per km. with steel masts.

Power Supply and Distribution

Energy for the line is derived from power stations at Goubakha (Kizel) and Berezniaki, which work in parallel on a 110 kV system. This system serves the town of Perm and the industrial area at Lysva, and has been prolonged to Sverdlovsk, feeding on the way the eight substations of the Chussovskaia—Sverdlovsk line, electrified during 1935-37. The Goubakha generating station burns coal mined in the district, and which has a calorific value of 5,445 calories per kg. (9,800 b.t.u.s per lb.); the consumption is about 1·57 kg. per kWh of energy measured at the substation busbars.

The feeding and location of the substations is shown in one of the accompanying diagrams. There are five on the Kizel-Chussovskaia line and eight from Chussovskaia to Sverdlovsk. The Kizel and Chussovskaia substations are supplied through short feeders from adjacent grid, or regional, substations, the feeders at Chussovskaia being underground. At Goubakha the substation is fed direct from the 6 kV busbars of the adjacent generating station. The maximum distance between substations is 30 km. (18·6 miles) on the Kizel—Chussovskaia line, but on the main line to Sverdlovsk the maximum distance is appreciably greater.

Because of regeneration, all substations are of the rotary-converter type, and a good deal of the equipment was supplied by the Metropolitan-Vickers Electrical Co. Ltd. Each sub has three converting sets running at 600 r.p.m., one of which is normally held in reserve. The 10-pole synchronous motors have a nominal capacity of 1,000kVA, a continuous output with cos ϕ 0·9, of 2,500 kVA; a two-hour capacity at cos φ 0·94, of 3,600 kVA; and a capacity for five minutes with cos ϕ 1·0 of 6,800 kVA. The nominal tension is 6,300 volts. A 26-kVA 147-volt exciter is attached to the motor. The d.c. generator has a nominal output of 1,000 kVA, a two-hour capacity of 1,500 kVA, and a five-minute capacity of 3,000 kVA; the generating tension is 1,500 volts, and each motor is ventilated by 12,000 cu. m. of air per min. A 14-kVA 110-volt exciter is fitted to the generator. A supplementary positive busbar protected by a high-speed breaker on the d.c. side enables repairs to be carried out after an accident without shutting down the substation.

Motive Power

The locomotives used over the Kizel—Chussovskaia line, and for freight trains over the Chussovskaia—Sverdlovsk route, are of the Soviet home-built standard Co-Co type, derived from locomotives first supplied from the U.S.A. and then from Italy. There are six nose-suspended motors giving an aggregate of 2,720 h.p. on the one-hour rating. Originally, the top speed was 70 km.p.h. (43·5 m.p.h.) but since hydraulic shock-absorbers were fitted the top limit has been increased to 100 km.p.h. (62 m.p.h.). The weight varies from 120 to 130 metric tons in the different batches.

SOUTH AFRICAN ELECTRIC FIGURES.—At the end of the financial year 1938-39 (March 31 last), the South African Railways had in traffic 179 electric locomotives and 212 electric motor-coaches, these figures being increases of 56 and 32 respectively during the year. The capital cost of the locomotives was £2,240,658, and of the motor-coaches £1,671,965. Eight more electric motor-coaches are to be built during the current year at a cost of about £92,000.

RAND ELECTRIC TRAFFIC.—With the exception of the nine-mile section between Canada and Village Main, the whole of the Witwatersrand passenger service is now operated by electric traction. The electrification of the Reef area was attended with numerous difficulties as a result of the phenomenal increase in suburban passenger traffic in which peak periods of unprecedented intensity were encountered. Operations which had been timed for certain periods of the day when occupancy of the track by the erection gangs could reasonably be expected were frequently hampered and delayed by the running of additional trains which had to be scheduled to cater for a rapidly-expanding suburban passenger service. As an illustration of the extent to which passenger traffic in the Witwatersrand area has grown, it may be stated that the number of passenger journeys increased from 25,639,266 in 1935-36, to 29,055,976 in 1936-37, to 31,787,889 in 1937-38 and to 37,142,471 in 1938-39.

Electric Railway Traction

Aluminium Transmission Cables

ON show at the Swiss National Exhibition at Zurich during the past summer were specimens of Aldrey, the latest Swiss aluminium alloy for e.h.t. overhead transmission cables. It has been used for some of the Swiss networks, and also, in cables of 95 and 130 sq. mm. cross-section, by the ex-Austrian Federal Railways for 20 miles of feeder lines in connection with electric traction. It is composed of 98·7 per cent. aluminium, 0·3 per cent. of iron, 0·5 per cent. of manganese, and 0·5 per cent. of silicon. For strands of 2 mm. to 3 mm. diameter, the guaranteed characteristics are: ultimate tensile strength 20 tons per sq. in., yield point 17·2 tons per sq. in., elastic limit 14 tons per sq. in., elongation on 20 diameters 5 per cent., modulus of elasticity 3,950 tons per sq. in., coefficient of expansion 0·000023, specific resistance 0·0333, electric conductivity at 20° C. 30, electric temperature coefficient 0·0036, and the specific gravity 2·7. For calculations on transmission line cables somewhat lower values are used, say, ultimate strength 19 tons per sq. in. for continuous cable temperatures of 80° C., elastic limit 11·5 tons per sq. in., elongation on 20 diameters 5 to 6 per cent., modulus of elasticity 3,550 tons, and the electrical conductivity at 20° C. up to 31 m./ohm. sq. mm. This alloy was evolved by the aluminium works at Neuhausen, near the Rhine Falls, but the later development has been in the hands of the Schweizerische Metallwerken Selve, at Thun.

Traction Motor Bearings

SOME of the details of traction motor construction seem to vary in America from what is found in Europe, for according to a report of the Association of American Railroads a number of waste-packed friction bearings are used for the motor armatures in electric shunting locomotives, whereas here the ball-and-roller type is almost universal for new construction for all classes of locomotives. American practice favours the ball-and-roller type for main line locomotives, and, in general, the grease cavities are filled to approximately half their capacity when the unit is placed in service; thereafter the pinion end is lubricated with from four to eight oz. of grease at intervals of from 4,500 to 23,000 miles. The armature end is lubricated with from four to 24 oz. of grease at intervals of approximately 20,000 miles. A good grade of ball-bearing grease is used, usually a brand recommended by the bearing manufacturer. In switching service invariably long-strand wool waste is used for packing, and the grade of lubricant used varies from S.A.E. 30 to a mixture of 50 per cent. car oil and 50 per cent. crankcase oil and various oils apparently purchased by brand. In general, the axle bearings of traction motors appear to be lubricated by long-strand wool-waste wick held securely against the journal by means of balls of waste, and often additional pressure is provided by means of a loaded steel plate. Two lines have experimented with force-feed lubrication to the oiled wick to ensure ample lubrication at all times. Some railways inspect and reservice these motor axle bearings after every trip, but others let them run for as much as 30 days before giving them attention. At one time a disturbing amount of trouble was developed in the armature roller bearings of the Zephyr trains. Eventually it was found that the pinion and gear contact at high speed generated enough heat to melt the adjacent bearing grease. Additional ventilation cured the trouble.

Belgian Electrification

THE electrification of the old double-track line between Brussels (Nord) and Antwerp on the 3,000-volt d.c. system has been completed, and an electric passenger service is scheduled to begin later this month. The trains on this line will stop at all stations, but the express and semi-fast electric trains between Brussels and Antwerp will continue to run over the other double-track route which was electrified in 1935, and which is composed partly of old lines and partly of new sections built in conjunction with the conversion. As the two sets of tracks are alongside, the existing electrified route mileage of 27½ will not be altered, but the track mileage will be increased by about 60. The new stock built for the route just converted comprises eight two-car non-articulated multiple-unit trains, each made up of two motor-coaches of steel construction. The tare weight is about 104 metric tons, and the top speed allowed is to be 120 km.p.h. (75 m.p.h.). Other electric rolling stock now being built is a total of 16 trailers, intended to make up the present Brussels—Antwerp four-car fast trains from four-car sets to six-car. This means that in future these trains will comprise two motor-coaches and four trailers, weighing about 315 metric tons, seating about 550 passengers, and with an installed motor capacity of 1,640 h.p. on the one-hour rating. The initial cost of the four-car steel sets built in 1934-35 was 5,028,617 Belg. fr. per set, and the purely operating cost, that is the working cost inclusive of maintenance and repairs, and amortisation on a life of 33 years for the electrical equipment and 40 years for the carriage portion, has amounted to about 6¼ Belg. fr. per train-km., of which the cost of current accounts for 2·16 Belg. fr. per km. The above working costs do not contain any allowance for substations or other stationary equipment connected with the electrification. Proposals for the electrification on the high-tension d.c. system of other Belgian lines have been made, particularly the Brussels (Midi)—Charleroi route, and eventually all of the Luxembourg line, both of which have heavy grades of 1 in 87 to 1 in 62, and carry a dense traffic. The Luxembourg line, like the Antwerp route just converted, has much international traffic, which, for a time, might continue to be operated by steam, as between Brussels and Antwerp, although as the line is much longer—140 miles from Brussels to Luxembourg city—it would pay to use electric locomotives.

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THE TYNESIDE ELECTRIFIED LINES OF THE L.N.E.R.

The present-day equipment and operation of one of the earliest English steam railways to be electrified, and which has recently been provided with modern rolling stock and equipment

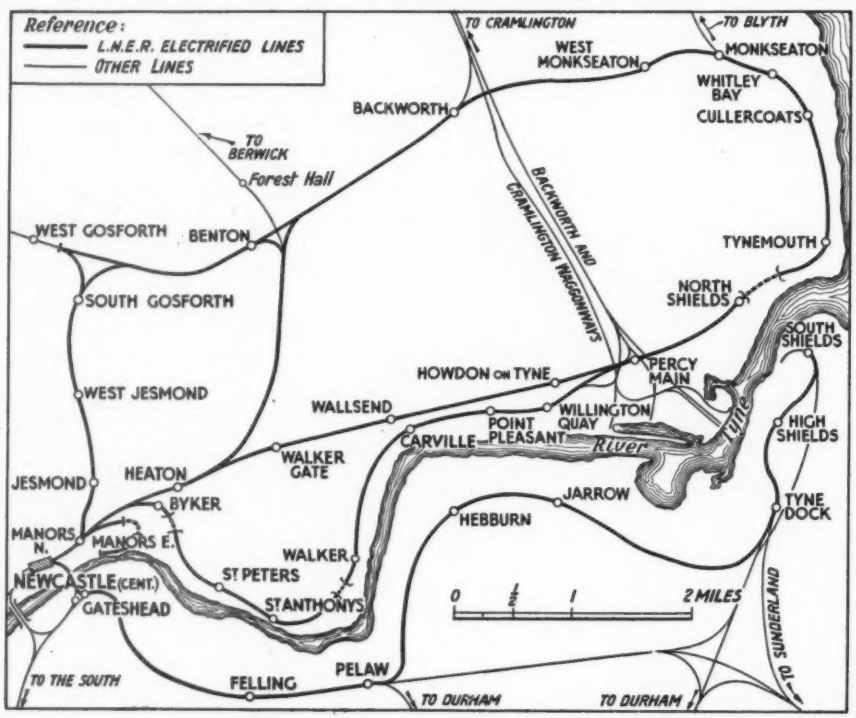
THE decision to electrify the North Tyneside suburban lines was made over 35 years ago, at a time when the North Eastern Railway had lost nearly a third of its passengers in this area by the electrification of the municipal tramways and by the opening of the Tyneside Tramways through route between Gosforth, Wallsend and North Shields. It was almost entirely the short-distance passengers who went to the trams, but the railway authorities realised that this was only natural, and concentrated on the retention and building-up of the longer-distance traffic, that is, from four to five miles upwards.

It was found that the faster, more frequent, and regular trains necessary to obtain this result could be obtained only by electric traction, and therefore in 1903 contracts were signed with the British Thomson-Houston and British Westinghouse companies for the conversion of the Newcastle(Central)—Wallsend—Whitley Bay—Gosforth—Newcastle(New Bridge Street) loop, together with the Riverside loop from Byker to Percy Main, and that portion of the Newcastle—Berwick main line lying between Heaton junction and Benton. Originally it was proposed to convert the Gosforth—Ponteland branch also, but this was never carried out and the line has been closed to passenger traffic since 1929.

Experimental running began between Carville and Percy Main in September, 1903, and an electric service between New Bridge Street passenger station and Benton was inaugurated on March 29, 1904. Electric services over the whole route began in July of the same year, and in 1909-10 a short length of new railway was constructed between New Bridge Street and Manors, thus enabling a through run to be made from the Central to the Central in each direction. Actually such a through service was not begun until March, 1917. New Bridge Street passenger station was demolished and its functions transferred to an extension of Manors station, known as Manors North, the older section then being renamed Manors East. In June, 1905, electric operation began on the short Quayside goods branch, which has grades as steep as 1 in 27. As with the suburban lines, d.c. at a tension of 600 volts was adopted, but overhead contact wires were installed in place of third rails in view of the shunting work carried out on the sidings at the quays. Three locomotives of the Bo-Bo type were built for this line, but the suburban routes have multiple-unit trains and motor parcels vans only.

The total electrified mileage at this stage was 31·8 route and 80·4 track, the track figure including 12·2 miles of sidings. No further extensions were made until March 14, 1938, when the South Shields branch, along the south bank of the Tyne, was opened to electric traction with multiple-unit trains. This conversion added 11·1 route and 24·3 track miles, giving present totals of 42·9 route and 104·7 track miles. From the opening in 1904, power has been purchased from the North-Eastern Electric Supply Co. Ltd., and such an arrangement was unusual at the beginning of the century, when it was customary for railways to build their own power stations for electric lines.

A total of 74 vehicles (39 motor-coaches, 33 trailers and 2 motor luggage vans) was built at a cost of £235,000 for the beginning of electrified working, and the cars provided a service of 195 trains a day at regular intervals,



Map of the north and south Tyneside lines electrified on the low-voltage d.c. system with conductor rail collection, and overhead wires on the Newcastle Quayside branch. The lines on the north bank of the river were electrified before 1914, and that on the south bank in 1938

Four-car electric train leaving No. 2 platform, Newcastle Central station, and crossing over on to the down Tynemouth line. The celebrated largest railway crossing in the world, leading from the station to the High Level bridge, is near the top left-hand corner of the picture

compared with the previous 121 steam trains a day at irregular times. By 1935 the stock had grown to 67 motor-coaches, 55 trailers, 4 motor luggage vans and a six-car compartment train of trailers, which provided 227 trains a day. Entirely new and completely renovated stock has been provided in the last two years as part of a big modernisation programme which included the electrification of the South Tyneside line, and the North and South Tyneside lines are now operated by 64 twin-car articulated sets, 36 modernised single-unit motor coaches and trailers, two new all-steel motor luggage thirds, two new parcels vans, one rebuilt 1920 parcels van, and a train of compartment-stock trailers, which is used only at peak traffic periods, when it is hauled by the four-motor luggage thirds.

Power Supply and Distribution

Three-phase current from the N.E.S. power station at Carville was supplied originally to four substations—Carville (or Wallsend), Cullercoats, Benton, and Pandon—at 40 cycles and a nominal tension of 6,000 volts. The original British-Westinghouse transformers were arranged with delta connection and fed 360-volt current to the converters. The rotaries had a continuous rating of 800 kW with a temperature rise not exceeding 35 deg. C., and could operate at a 50 per cent. overload for three hours without a temperature rise exceeding 60 deg. C. Each rotary was started by a polyphase induction motor. The combined efficiencies of the transformer-rotary sets were 93·9 per cent. at full to one-and-a-half times full load, 93·4 per cent. at three-quarter load, and 91·9 per cent. at half load. An illustrated description of the original substation equipment is given in *Electric Railway Engineering*, by Parshall & Hobart, 1907.

With the modernisation programme of 1933-38, the supply was changed to 50 cycles at a nominal tension of 5,750 volts, and new Metro-Vick rotary converters and transformers were installed in 1934. All these substations are of the rotary converter type with machines of 1,000 kW capacity; Pandon and Cullercoats have three sets and the remainder two each. It was intended originally that there should also be a 2,000-kW substation at Kenton, to feed the Ponteland branch. Wallsend substation has feeders to both the Riverside and circle lines. The old switchgear was retained. To assist traffic operation, two new rotary converter substations were installed, one at Gosforth East, in 1933, and one at Earsdon Grange, in 1934. Both have one 1,000-kW set, but at Earsdon Grange the three-phase supply is at 20 kV. The rotary machines replaced two of the 1904 sets taken from other substations, and new h.t. metal-clad oil switches and d.c. high-speed breakers were provided. The installation of these sets has considerably eased the conditions in the Newcastle area, where previously Pandon substation supplied the heavy current needed by three or four trains starting or accelerating at the same time from the Central or Manors, one of them probably being up the 1 in 75 from Manors North, and also up the flatter grades near Earsdon and Benton. All the original substations were and are manually operated, but Gosforth East and Earsdon Grange are remotely-controlled from Benton and Cullercoats substations respectively. The high-tension current is transmitted through underground cables, and this system has been adopted also for the supply to the newly-electrified South Tyneside line, for which the primary feeder cable from the N.E.S. plant at Carville is led directly under the river in the supply company's existing cable tunnel.

Four remotely-controlled rectifier substations—Gateshead, Pelaw, Jarrow, and Tyne Dock—convert the three-phase 5·75 kV 50-cycle supply for the South Tyneside line, and as with the rotary converter sets on the north bank, produce d.c. with a nominal tension of 630 volts at the substation busbars. Pelaw and Tyne Dock have two 1,000 kW rectifiers each, and Gateshead and Jarrow one set. The control is effected from Wallsend by means of supervisory gear. The principal facilities provided comprise the individual control of each rectifier and track feeder, simultaneous operation in pairs of breakers at the two ends of particular track sections, telephone communication between substations and control room, and remote indication of busbar voltage, control battery voltage, and total d.c. current at each substation.

At Jarrow the substation plant is housed in a portion of an existing building rented from the supply company; for the remaining equipment new buildings were erected at Gateshead, Pelaw, and Tyne Dock. The dimensions of these buildings were kept as small as possible consistent with reasonable accessibility for maintenance, and a novel scheme of ventilation was adopted whereby the air for the closed-circuit cooling system of the rectifier can be drawn

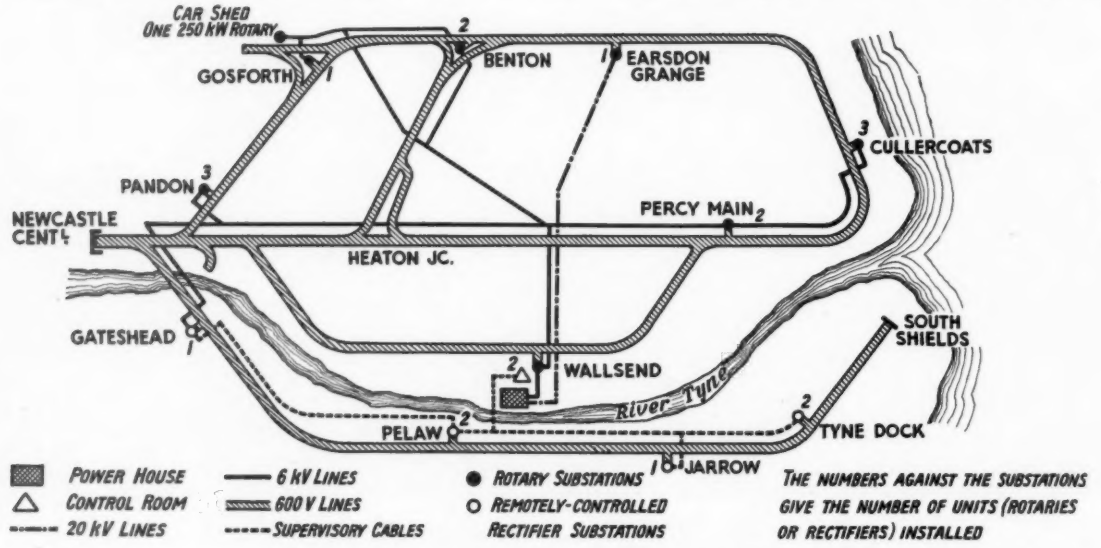
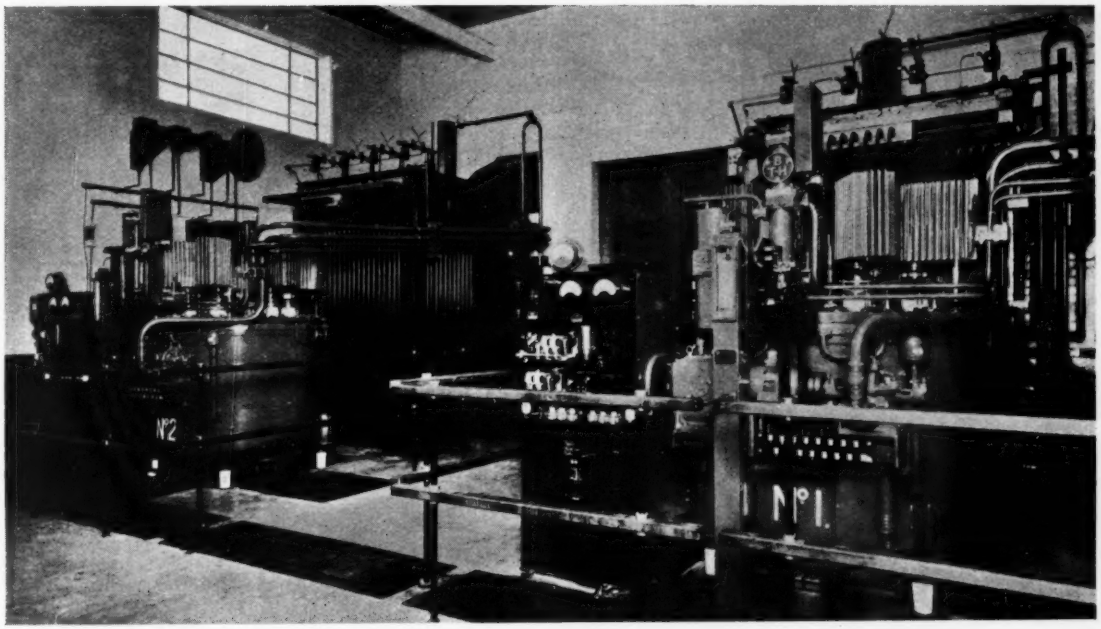


Diagram of power supply and distribution system, Tyneside electrified lines, L.N.E.R. The substations on the South Shields line have separate feeders at a tension of 5,500 volts owned by an independent supply authority

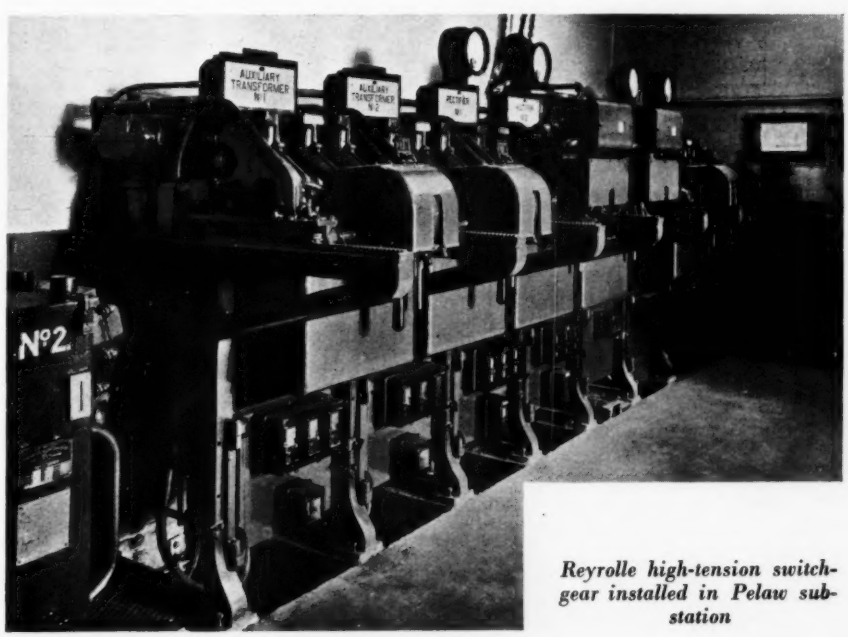


Interior of Pelaw substation on the South Shields line, showing the two 1,000-*kW B.T.H. rectifier sets*

from and discharged to the outside of the building, or alternatively circulated entirely within the substation. The heat dissipated in the rectifier recooler can therefore be used to warm up the substation in winter, and discharge outside the building in summer, thus maintaining a reasonably constant substation temperature regardless of seasonal variations. Since in the one case only the air already in the substation is circulated, and in the other the air drawn from outside passes only through the fan and cooler, there is no appreciable interchange of air between the inside and the outside of the building under either condition of operation. The arrangement therefore has the further advantage of keeping the plant in a much cleaner condition than would be the case were free circulation of air permitted, and it may be expected that maintenance charges will thereby be reduced.

There are six rectifiers of the six-anode water-cooled type, each rated at 1,000 kW 630 volts and capable of carrying overloads of 25 per cent. for two hours, 50 per cent. for one hour, and 200 per cent. for 15 sec. In accordance with normal B.T.H. practice the water circulating pump, vacuum pumps, and gauges are mounted on the rectifier tank, the water coolers being carried on insulators and electrically connected to the water jackets. The entire water circuit is thus maintained at the potential of the rectifier tank and all risk of electrolytic action is avoided. Smoothing equipment is provided, and comprises an air core d.c. reactor and four tuned shunt circuits for each rectifier; the design of the equipment gives a degree of immunity from interference with communicating circuits comparable with that obtained with well-designed rotating plant.

The rectifier transformers are of the oil-immersed self-cooled type, and both main and interphase units are housed in a common tank. A tertiary winding on the main transformer provides the necessary heavy current low-voltage supply for baking out in the event of a rectifier having to be opened up at any time; facilities for a quick change-over from normal to bake-out connections are given by removable links in the main a.c. connections. A single bake-out resistance is available, this being arranged in a portable form for easy transport from one substation to another on both North and South Tyneside routes.



Reyrolle high-tension switchgear installed in Pelaw substation

XUM

B.T.H. direct-current switchgear and high-speed circuit-breakers in Pelaw substation

At each substation the supply company's 5,750-volt feeder cables terminates in Reyrolle hand-operated oil circuit-breakers. A motor-operated oil circuit-breaker and a hand-operated oil circuit-breaker for each rectifier completes this switchboard, the former controlling the rectifier transformer and the latter a 25 kVA control transformer which supplies the rectifier auxiliaries. Arrangements are made so that single-phase supplies may be taken from the control transformers for substation lighting and for signal operation, a changeover switchboard being provided in the double-unit substations to enable these circuits to be fed from either transformer at will. The switchgear is of the horizontal draw-out metal-clad pattern, with single busbar 300-amp. 5,750-volts three-phase 50-cycles oil-immersed circuit breakers having a rupturing capacity of 150,000 kVA. Pelaw and Tyne Dock substation h.t. switchboards comprise two incoming feeder panels, a busbar continuity-type metering panel, two rectifier panels, and two auxiliary transformer panels. The circuit breakers are all hand-operated, except on the rectifier panels, which are motor-operated.

On the d.c. side the rectifiers are protected by reverse tripping high-speed circuit-breakers which, together with the forward tripping high-speed circuit-breakers controlling the track feeders, of which there are four per substation, are housed in an annexe. The high-speed circuit-breakers are carried on a shelf below which are mounted the d.c. busbars and isolating switches. Interconnecting switches are provided between pairs of outgoing track feeders to enable one breaker to feed two tracks for short periods when maintenance work on a breaker is carried out. One feeder in each pair is arranged so that when the busbars are dead the control supply for its high-speed breaker is automatically transferred to the track, thus permitting feeding through when a substation is shut down. The automatic control panels for starting and protecting the rectifiers are mounted in an opening in the wall between the machine room and the d.c. switchgear annexe, together with the supervisory control cubicle and a small loading panel to suppress the no-load voltage rise of the rectifiers.

One of the first portions of the £500,000 improvement scheme of 1933-38 was the replacement of the original 95 lb. conductor rails by others of the 120 lb. section, in order to reduce the voltage drop, and to lay these new rails to the Ministry of Transport standards of 16 in. from the centre of the third rail to the inside face of the running rail and 3 in. above the running rail, compared with the 19¼ in. and 3¼ in. of the original position, which, as far as centre distance was concerned, was in accordance with the Railway Clearing House recommendation of 1903. The new conductor rails were laid gradually from 1934 onwards, but the change-over of the rail position was effected at one fell swoop on May 22-25, 1936, during which days a special steam service was substituted. Details of the change-over will be found in the issues of this Supplement for May 29 and June 26, 1936. The 120 lb. rails are used on the South Shields line also. They are of flat-bottomed section, rolled in 60-ft. lengths, and the sectional area is 12 sq. in., equivalent to 1·85 sq. in. of copper.

The charge for current consumption is based on the maximum half-hourly load attained throughout the year, the load including traction, train lighting, and station lighting. Before the South Tyneside line was electrified,

TABLE I.—L.N.E.R. : NORTH EASTERN AREA.
Electric Train Working—North Tyne
Four weeks ending October 29, 1938

Description of work	Train mileage	Car mileage			Other vehicles	Total
		Motors	Trailers	Total elec. stock		
Loaded trains ..	84,052	—	—	426,203	4,659	430,862
Empty trains ..	6,901	—	—	34,733	3,535	38,268
Loaded and empty	90,953	—	—	460,936	8,194	469,130
Shop purposes and trials ..	63	—	—	152	20	172
Total ..	91,016	233,608	227,480	461,088	8,214	469,302

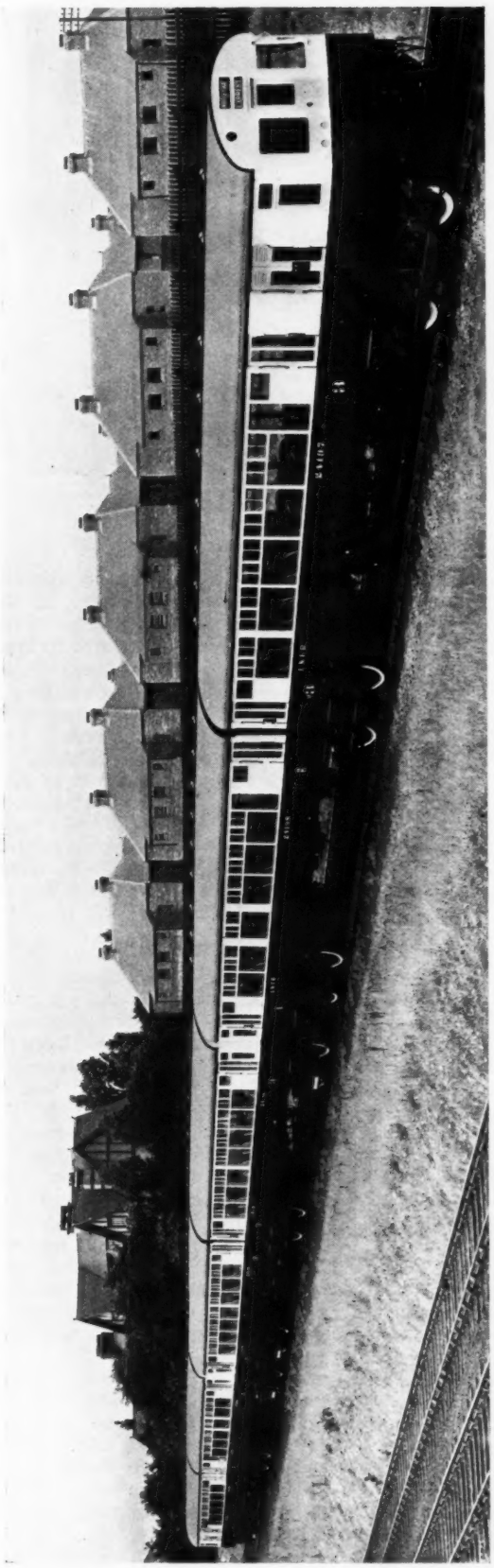
Electric Trains—Hours and Wages

	Train hours	Shop purposes and trials	Total hours	Motormen's pay bill hours	Motormen's wages
					£ s. d.
Total ..	5,862	6	5,868	8,095	847 19 0

Cost of Electric Current

	Units	Per unit d.	£ s. d.
Electric trains	1,275,923	0·720	3,827 15 5
Lighting of trains	19,465	0·720	58 7 11
Electric locomotives	7,512	0·720	22 10 9
Lighting of stations, &c. ..	24,827	0·720	74 9 7
Total	1,327,727	—	3,983 3 8

the annual h.t. consumption (substation input) amounted to just over 16,000,000 kWH for a train mileage of 1,216,245, the simultaneous maximum half-hourly h.t. demand being about 5,000 kW. Recent figures for h.t. simultaneous half-hourly demands are 5,500 kW for the North Tyneside lines and 2,180 kW for the South Tyneside lines. Since the electrification of the line along the south bank the annual current consumption has risen to about 23,000,000 kWh and the train miles to 1,536,952.



One of the new Metro-Cammell trains made up of four twin-car articulated sets, Tyneside lines, L.N.E.R.

Of these totals 19,000,000 kWh are for the North Tyneside lines and 4,000,000 for nine months' operation on the South Tyneside lines; the respective train mileages were 1,232,853 and 304,109. The gross ton-miles per single track running mile per annum over the North Tyneside lines approximates to 2,700,000 and the maximum hourly train mileage occurs between 8.0 a.m. and 9.0 a.m., when it averages 196. The car-miles per train-mile average about 5.3, and the train-miles per train-hour 15·4. Figures for a recent four-weekly period on the North Tyneside lines are given in Table I.

Rolling Stock

The 74 original open-type vehicles of 1904 were supplemented by 16 others to the same general design in 1913-14. On August 11, 1918, a serious fire at Walker Gate sheds caused the loss of 19 motor-coaches and 15 trailers, but by 1922 these had been replaced by a similar number of new vehicles, and at the same time another motor luggage van was built. The original motors were of the G.E.66 type with a one-hour rating of 125 h.p., the temperature rise for the rating at that date being 75° C. In the first post-war stock, G.E. 254B motors were used, and had a one-hour rating of 140 h.p. The original trailers seated 70 third class passengers within a body length of 56½ ft. and the first class motor-coaches, which had two driving compartments and a luggage van, 48 passengers. The 1921 stock had 72 third class seats in the trailer on a tare weight of 25½ tons, and the motor-coaches were arranged to take both first and third class passengers in addition to having a luggage compartment and one driving compartment; there were 24 first class and 28 third class seats on a tare weight of 33·85 tons.

Of the 132 cars existing in 1934, a total of 90 have been withdrawn and replaced by 64 new twin-car articulated sets and four single-unit motor vans; 36 of the remaining vehicles have been modernised, all in the mechanical, electrical, and braking equipment. The six vehicles not classed as being modernised are the six compartment coaches forming the special peak-period train hauled by the four-motor luggage thirds, but even these have been re-upholstered and improved in sundry details.

The new twin-car sets are of four types, viz.:—

		Seats		
		1st	3rd	
Driving luggage motor third	18 sets	—	52	D
Trailer first		60 or 28	— 36	
Driving motor third	18 sets	—	64	C
Trailer third		—	68	
Driving luggage motor third	16 sets	—	52	B
Driving trailer first		60 or 28	— 32	
Driving motor third	12 sets	—	64	A
Driving trailer third		—	64	

Articulated trains C and D have only one driving cab, and thus are not suitable for operation as twin-car sets running alone.

Bucket seats are used in all cases, in preference to the old reversible and non-reversible rattan seats, and although they improve the comfort, the total carrying capacity of a train has been somewhat reduced. A six-car train of 1921 build seated 44 first class and 340 third class passengers on a tare weight of 179 tons and within a body length of 342 ft., and had a one-hour h.p. of 840. The corresponding figures for three of the new twin-car sets coupled in multiple-unit are 56 first class and 308 third class seats on a tare weight of about 168 tons and within a length of 336 ft. and with a one-hour h.p. of 1,296. The new sets were built by the Metropolitan-Cammell Carriage & Wagon Co. Ltd., and have steel bodies and underframes; the bodies are of riveted construction with certain minor joints welded, but the underframes are of all-welded construction. Alpax sliding

Interior of one of the electric cars built in 1922, and fitted with rattan seats

Interior of one of the new electric cars fitted with the latest type of bucket seats

doors are located at each end of each car, and the interior finish is of Rexine. The bogie frame structures are riveted, and the bogies have 3 ft. 7 in. wheels spread over a base of 8 ft., compared with the 3 ft. wheels and 7 ft. wheelbase of the earlier stock. The axleboxes are of the plain bearing type with Armstrong lubricators, except on two twin-car sets which have Hoffmann roller bearing boxes. Westinghouse electro-pneumatic brake equipment is incorporated in the new stock and has also been installed in the rebuilt cars.

The motor-coach of each twin-car set is equipped on the outer bogie with two nose-suspended self-ventilated motors with a continuous rating of 154 h.p. at 210 amp. 600 volts, and a one-hour rating of 216 h.p. at 295 amp. 600 volts. Spur gears of forged carbon steel, heat-treated after cutting, are used; they have a ratio of 71:18 and are enclosed in a pressed steel gear case having three-point suspension. The motors normally operate in parallel at 60 per cent. of full field strength, and the equipment has been designed for maximum accelerating current of 300 amp. per motor.

Car Repairs and Working

The rolling stock maintenance and repair depot is situated at Gosforth car sheds, alongside the junction to the Ponteland branch. The shed section contains 10 roads, each with room for 12 cars under the roof, and each provided with lighted pits. Three of the roads have hot and cold water points and a vacuum servicing supply. Alongside is the repair shop, where repairs and overhaul of the electrical equipment, mechanical portion and brake apparatus of the multiple-unit trains and the Quayside branch locomotives are carried out.

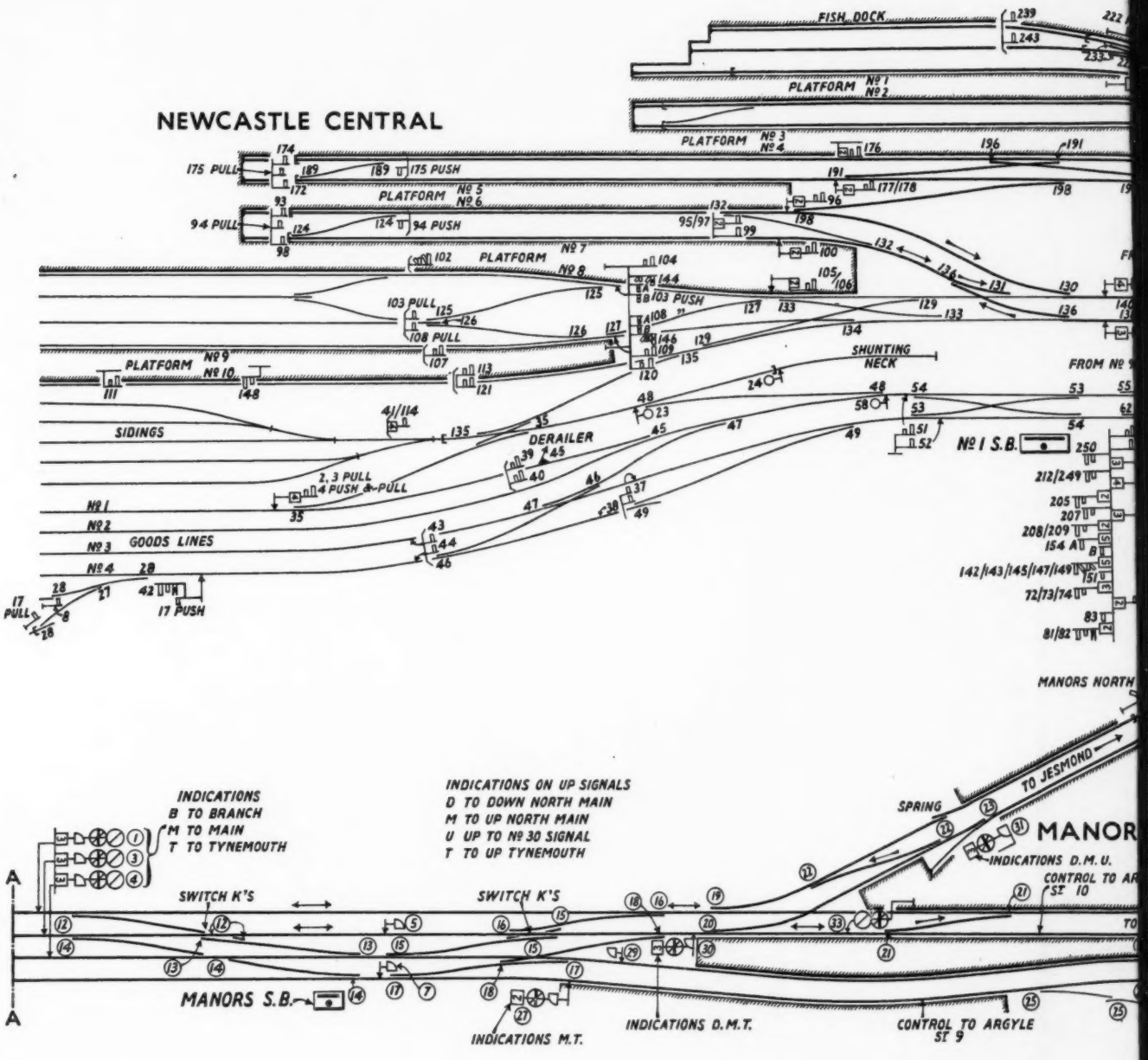
Gosforth depot is the headquarters of the stock used on the North and South Tyneside lines, and car working is so arranged that the individual South Tyneside sets spend alternate nights at the depot. Each of the articulated twin-car units for the north side services is in the depot each day for cleaning and servicing. The train set rosters are drawn up so that in a three-weekly period each unit is in the depot one full day for maintenance, one full day for cleaning, and one part day for cleaning, this being in addition to the regular day by day cleaning when the cars are in the depot.

For weekday operation over the North Tyneside lines the articulated trains are divided up into 15 sets, of which nine are eight-car formations, four are six-car sets, and three are four-car sets. Five of the eight-car make-ups are divided up into two fours during the slack periods. To allow for the cleaning requirements, three of the eight-car formations, one of the six-car, and one of the four-car sets are out on the line only for a three to four-hour period on any normal day. The operation of the South Tyneside line weekday service calls for six six-car sets at the peak periods of the day, with a reduction in the number of vehicles operating at slack times. Two sets are stabled at South Shields overnight, one at Pelaw, and three at Gosforth. One motor parcels van is allocated to this branch, but at the moment runs only one return trip a day, making the rest of its mileage north of the river. The three motor parcels vans are equipped with motor-driven exhausters and vacuum brake valves so that they can handle trains of pipe-fitted covered wagons when required.

Traffic Operation

Constant detail improvements are being made in the arrangements for efficient traffic operation, and when the 1933-38 modernisation programme was under way a number of modifications, alterations and new works were sanctioned in order to improve operation and increase the traffic. Principal among these were the construction of a new station, West Monkseaton, opened in 1933; the widening of North Shields tunnel to enable two steam or electric trains to pass each other on the curve; lengthening of certain platforms; reduction in the station stop time; institution of either-way working between Newcastle and Manors; installation of a modernised booking office at Newcastle and a passimeter office at Whitley Bay; and the new rolling stock and conductor rails mentioned in preceding sections. Little could be done with the intensive freight traffic in the area, except to ensure that the maximum possible punctuality at all points was observed both by freight and electric passenger trains.

The normal week-day service on the North Tyneside lines is based on eight trains per hour to and from the coast. One stopping train leaves Newcastle every 20 min. *via* the north side and one every 20 min. *via* the south side of the circle. The trains *via* Wallsend (south side) leave at 15, 35, and 55 min. past the hour, and the trains *via* Benton leave at 5, 25, and 45 min. past the hour. A train leaves once an hour, *i.e.*, at 20 min. past the hour, for the Riverside loop, stopping at all stations to Tynemouth; the set then forms an hourly express from the coast to Newcastle. Similarly, an express leaves Newcastle every hour for the coast and the set returns as a


NEWCASTLE CENTRAL
FISH DOCK
PLATFORM Nº 1 Nº 2
PLATFORM Nº 3 Nº 4
PLATFORM Nº 5 Nº 6
PLATFORM Nº 7 Nº 8
PLATFORM Nº 9 Nº 10
175 PULL
175 PUSH
94 PULL
94 PUSH
103 PULL
103 PUSH
108 PULL
SHUNTING NECK
SIDINGS
DERAILER
2, 3 PULL 4 PUSH & PULL
Nº 1
Nº 2
Nº 3 GOODS LINES
Nº 4
17 PULL
17 PUSH
Nº 1 S.B.
FROM Nº
MANORS NORTH
TO JESMOND
SPRING
MANOR
INDICATIONS D.M.U.
CONTROL TO AR
SI 10
INDICATIONS
B TO BRANCH
M TO MAIN
T TO TYNEMOUTH
INDICATIONS ON UP SIGNALS
D TO DOWN NORTH MAIN
M TO UP NORTH MAIN
U UP TO Nº 30 SIGNAL
T TO UP TYNEMOUTH
SWITCH K'S
SWITCH K'S
MANORS S.B.
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CONTROL TO ARGYLE
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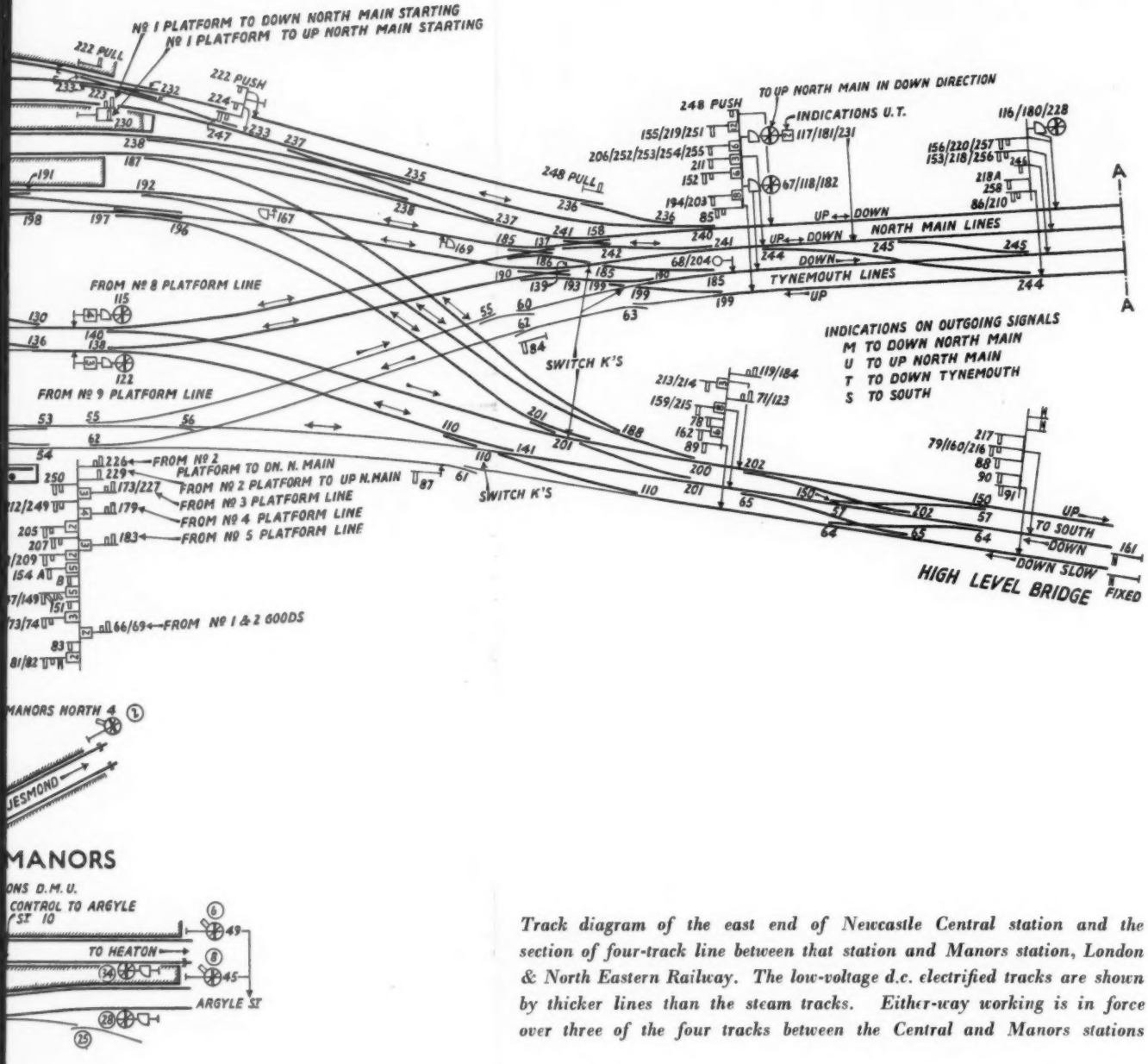


Track diagram of the east end of Newcastle Central station and the section of four-track line between that station and Manors station, London & North Eastern Railway. The low-voltage d.c. electrified tracks are shown by thicker lines than the steam tracks. Either-way working is in force over three of the four tracks between the Central and Manors stations

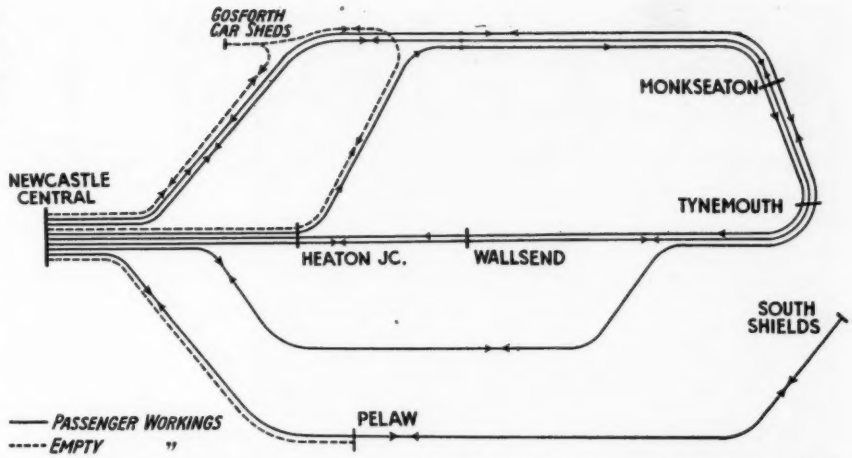


Diagram showing the various train services operated by multiple-unit electric trains over the north and south Tyneside lines, and radiating from Newcastle Central station

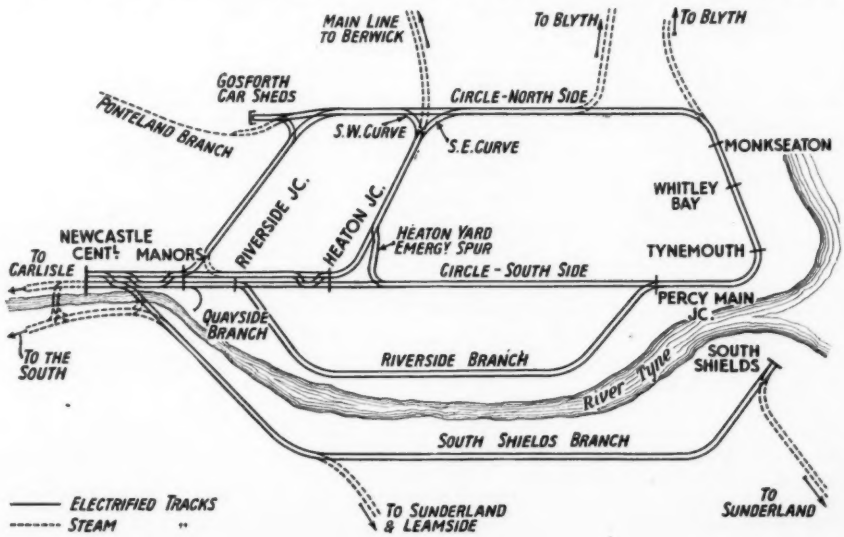
stopping train from Tynemouth to Newcastle *via* the Riverside loop. Thus the maximum interval between the departures of trains from Newcastle to the coast is 10 min. Trains can be used indiscriminately by passengers between Newcastle and the coast stations at Monkseaton, Whitley Bay, Cullercoats, and Tynemouth, and the journey time by either side of the circle varies only by a minute or two. Expresses to and from the coast normally travel *via* the Benton route, passing Backworth, Benton, South Gosforth, West Jesmond, and Jesmond stations. At business rush periods, however, when the interval service is considerably augmented, it is not always possible to find a path for express trains *via* Benton and so use is made of what is known as the South-East Curve, which connects the north side of the circle with the main line at Benton Quarry, north of Heaton junction.

Since the new stock was put into operation the time for the regular circle stopping trains over the 20·6-mile journey is 53 min. inclusive of 18 intermediate stops. A nominal allowance of 20 sec. per stop is made at all stations except Benton, West Monkseaton, Percy Main, Howdon, and Walker Gate, where, owing to lighter traffic, the allowance is 15 sec. The schedule time of a train operating an express service from Newcastle to the coast and then returning as a Riverside stopping train is 53 min. in one direction and 52 min. in the other direction. The circular journey is slightly longer, but owing to express running the trains are able to complete the trip in the same time as the regular stopping trains round the main circle. The nominal allowance per stop at Riverside branch stations is 15 sec. The point-to-point allowances both-ways round the circle are as given in Table II.

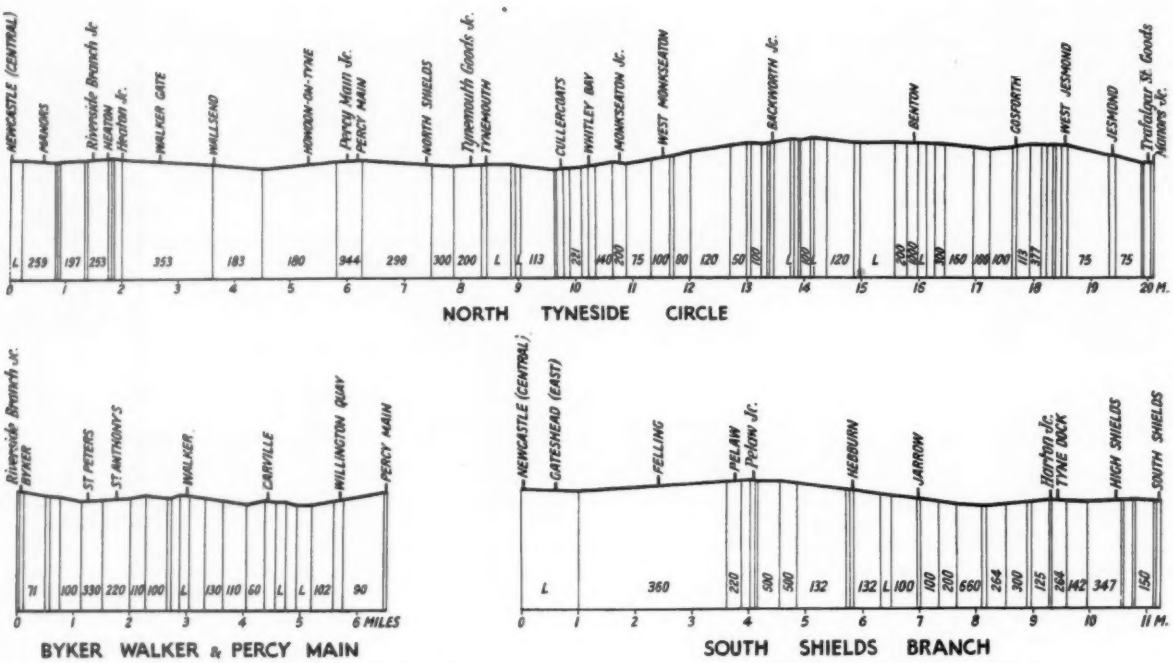
Platforms 1, 2, and 3, and at times No. 4, are used at Newcastle Central for the North Tyneside trains. As a general rule there is a 3 min. gap between the departure of one train and the next arrival at the same platform. The lie-over of a set at the Central varies from 7 to 15 min. Particulars of the platform and set working during an ordinary two-hour period in the morning are given in Table III.

In Table III the down trains are shown as going to Monkseaton—if running first along the south line *via* Wallsend, or to Tynemouth—if running first *via* Gosforth and Benton. For timetable purposes these trains are considered as changing from out to home at Monkseaton and Tynemouth respectively, and in the arrivals column are shown as originating at those places although they are actually through trains. Tynemouth is the direction changeover point for Riverside trains in either direction.

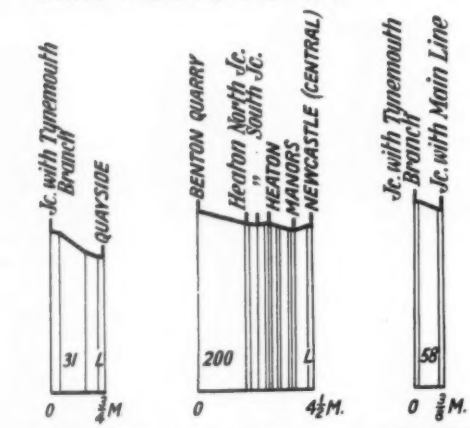
At business periods the service is augmented, principally by express trains serving only the four coast stations, and then running as stopping trains in the up direction. For example, from 5.0 p.m. to 6.0 p.m. there are ordinary departures *via* Gosforth and Benton at 5.5, 5.25, and 5.45; ordinary departures *via* Wallsend at 5.15, 5.35, and 5.55; the ordinary Riverside departure at 5.20; express depar-



Track diagram of the electrified routes in the vicinity of Newcastle. From Newcastle Central station to Heaton junction there are four tracks; with the exception of the Quayside branch the remaining electrified lines are double track



Gradient profiles of the L.N.E.R. electrified lines on the north and south banks of the River Tyne



tures *via* Benton at 5.0, 5.40, and 6.0, and express departures *via* Wallsend at 5.10 and 5.33. The 5.0, 5.10, 5.25, 5.40, and 6.0 trains are normally eight-car formations, the 5.5, 5.15, 5.35, and 5.45 are six-car sets, and the 5.20 and 5.33 are four-car make-ups. The total seating capacity available in the down direction over this hour is thus in the neighbourhood of 4,500, but the standing room is sufficient to bring the carrying capacity up to about 8,000. There is also a minor rush period in the middle of the day, enabling residents at the seaside to go home for lunch; there are 12 departures between 12.0 noon and 1.7 p.m. and 12 arrivals between 1.9 and 2.18 p.m. There are also a number of workmen's trains in the early morning and evening and at the lunch hour on Saturdays. The majority of these are used by workmen travelling between Newcastle and the shipyards in the Walker, Wallsend, and Willington Quay districts. There are also a considerable number of workmen travelling from coast stations to these yards, and North Shields is also a busy station for workmen and for other classes of travel.

Mention has been made earlier of the South-East Curve joining the Berwick main line with the north side of the electrified circle. There is also a South-West Curve which is available for electric trains travelling from Newcastle *via* the Berwick main line to Gosforth car sheds. One up and one down electrified tracks have also been provided through Heaton carriage sidings and connecting the Berwick main line with the Wallsend route.

There are 173 departures a day from Monday to Friday from the Central, serving the circle and the Riverside

TABLE II.—NORTH TYNESIDE LINES: RUNNING AND STATION ALLOWANCES

Stopping trains round the circle *via* Wallsend	Running time	Station time	Theoretical departure time	Timetable time
	Min. sec.	Min. sec.	Min. sec.	Min.
Central–Manors East	2 0	0 20	2 20	2
Manors East–Heaton	2 16	0 20	4 56	4
Heaton–Walkergate	2 6	0 20	7 22	7
Walkergate–Wallsend	2 18	0 20	10 0	10
Wallsend–Howdon	2 38	0 20	12 58	12
Howdon–Percy Main	2 0	0 20	15 18	15
Percy Main–North Shields	2 16	0 20	17 54	17
North Shields–Tynemouth	2 35	0 20	20 49	20
Tynemouth–Cullercoats	2 40	0 20	23 49	23
Cullercoats–Whitley Bay	1 31	0 20	25 40	25
Whitley Bay–Monkseaton	1 44	0 20	27 44	27
Monkseaton–West Monkseaton	1 50	0 20	29 54	29
West Monkseaton–Backworth	3 26	0 20	33 40	33
Backworth–Benton	4 10	0 20	38 10	38
Benton–South Gosforth	3 30	0 20	42 0	42
South Gosforth–West Jesmond	2 0	0 20	44 20	44
West Jesmond–Jesmond	1 50	0 20	46 30	46
Jesmond–Manors North	3 30	0 20	50 20	50
Manors North–Central	2 30	(arr.)	52 50	53
Summary	46 50	6 0	52 50	53
Central–Manors North	1 56	0 20	2 16	2
Manors North–Jesmond	1 39	0 20	4 15	4
Jesmond–West Jesmond	2 1	0 20	6 36	6
West Jesmond–South Gosforth	2 8	0 20	9 4	9
South Gosforth–Benton	3 38	0 20	13 2	13
Benton–Backworth	4 0	0 20	17 22	17
Backworth–West Monkseaton	3 30	0 20	21 12	21
West Monkseaton–Monkseaton	1 54	0 20	23 26	23
Monkseaton–Whitley Bay	1 40	0 20	25 26	25
Whitley Bay–Cullercoats	1 25	0 20	27 11	27
Cullercoats–Tynemouth	2 41	0 20	30 12	30
Tynemouth–North Shields	2 48	0 20	33 20	33
North Shields–Percy Main	2 40	0 20	36 20	36
Percy Main–Howdon	1 59	0 20	38 39	38
Howdon–Wallsend	2 54	0 20	41 53	41
Wallsend–Walkergate	2 27	0 20	44 40	44
Walkergate–Heaton	2 16	0 20	47 16	47
Heaton–Manors East	3 20	0 20	50 56	50
Manors East–Central	1 54	(arr.)	52 50	53
Summary	46 50	6 0	52 50	53

route, and of these 15 are empties running to Gosforth sheds and eight are parcels vans worked by the electric motor vans. The empties are most frequent just after the morning rush hour—there are eight between 8.36 and 10.10, two of them running *via* Heaton and the west curve. On Saturdays the normal booked departures from the Central amount to 167, of which 14 are empties and eight are parcels trains.

Sunday and Holiday Operation

On normal Sundays during the winter and spring periods a half-hourly service operates on both the North and South Tyneside lines. Trains leave Newcastle for the coast at 5 and 35 min. past the hour *via* Benton and at 20 and 50 min. past the hour *via* Wallsend. There are thus four trains an hour evenly spaced between Newcastle and the coast. The size of the train sets is gradually increased from two coaches to six coaches as the day goes on.

The above working, however, can only apply on normal winter and spring Sundays. In summer, owing to the proximity of Tyneside to the sea there are enormous variations in the volume of traffic to be carried, the variations being dependent mainly on weather conditions. Owing to the short distance, brief journey time, and cheap fares, the traffic goes up and down virtually without notice. A dull Sunday morning, or two or three wet days beforehand, may bring only normal traffic, but if the weather clears up by lunch time there may be a rush to the coast between 1.0 p.m. and 3.0 p.m. with a heavy return flow between 7.30 p.m. and 10.0 p.m. On a fine summer Sunday the down traffic may be maintained at a high level from 10.0 a.m. to 3.0 p.m., and the return traffic may be concentrated over a period of two and a half hours, generally from 7.30 p.m. to 10.0 p.m. Similarly, a change for the worse in the weather during the afternoon or early evening upsets the pre-arranged working for the return traffic by bringing anything up to 50,000 people home earlier than expected.

The arrangements made to cater for these variations in summer Sunday traffic include the manning of a special emergency sub-control for the electrified area on the north bank of the Tyne, and the provision of special pre-arranged emergency services varying in accordance with the volume of traffic. Three special services have been planned for the North Tyneside services to cater for varying volumes of traffic, the particular service to be operated

TABLE III.—PLATFORM OCCUPATION, NEWCASTLE CENTRAL, MONDAYS TO FRIDAYS.

No. of cars.	Set No.	From	Time of arrival.	Platform.	Time of departure.	To
			a.m.		a.m.	
5	4	Tynemouth, via Riverside	10 7	3	10 15	Monkseaton, via Wallsend.
9	6	Tynemouth, via Benton ..	10 9	1	10 25	Tynemouth, via Benton.
6A	4	Tynemouth, E.P., via Benton	10 13	2	10 20	Tynemouth, via Riverside.
6B	4	Tynemouth, via Wallsend	10 18	3	10 35	Monkseaton, via Wallsend.
11	4	Tynemouth, via Benton ..	10 28	1	10 45	Tynemouth, via Benton.
10A	4	Monkseaton, via Wallsend	10 38	3	10 55	Monkseaton, via Wallsend.
3B	4	Tynemouth, via Benton ..	10 48	2	11 0	Monkseaton, via Benton, E.P.
12A	4	Tynemouth, via Riverside	10 52	1	11 5	Tynemouth, via Benton.
12B	4	Monkseaton, via Wallsend	11 0	3	11 15	Monkseaton, via Wallsend.
5	4	Tynemouth, via Benton ..	11 8	2	11 20	Tynemouth, via Riverside.
6A	4	Tynemouth, E.P., via Benton	11 13	1	11 25	Tynemouth, via Benton.
9	6	Monkseaton, via Wallsend	11 18	3	11 45	Tynemouth, via Benton.
6B	4	Tynemouth, via Benton ..	11 28	2	11 35	Monkseaton, via Wallsend.
11	4	Monkseaton, via Wallsend	11 38	2	11 55	Monkseaton, via Wallsend.
		2 cars arriving 9.58	a.m.	off	Set 7	attached.
					p.m.	
10A	4	Tynemouth, via Benton ..	11 48	1	12 5	Tynemouth, via Benton.
3B	4	Tynemouth, via Riverside	11 52	1	12 0	Monkseaton, via Benton E.P.
12A	4	Monkseaton, via Wallsend	11 58	2	12 10	Monkseaton, E.P., via Wallsend.
			p.m.			
14	8	Gosforth Sheds	12 6	3	12 15	Monkseaton, via Wallsend.
		2 cars detached for	1–20	p.	m. Set	3A.

Passengers de-training from four-car set at No. 2 platform, Newcastle Central station

being decided on the Saturday morning by the District Superintendent and the District Passenger Manager on the basis of weather reports, general experience of the habits of passengers, and other considerations. The inspector in charge of the emergency sub-control can alter this service at his discretion if the weather should change. Notices are sent out immediately to station staffs, signalboxes, car sheds, and to the electrical engineer, intimating the services which are to operate, as these considerably affect the numbers of cars and the staff to be brought on duty. When the maximum service is in operation additional plant has to be brought into use at Wallsend substation.

The three special services are planned on the basis of the ordinary advertised services shown in the public timetable and these trains have to run as advertised. Service A, which is the lightest of the three, comprises 6 six-car and 4 eight-car sets, that is, an increase of three sets over the ordinary service, and gives approximately 90 departures from Newcastle Central. Service B comprises 7 six-car sets and 6 eight-car sets, giving over 100 departures from Newcastle Central. Service C, which is the maximum service operated, consists of 12 six-car sets and 5 eight-car sets, giving over 100 departures from Newcastle Central, and an additional 15 departures from Manors North. The latter trains principally serve intermediate stations and relieve stopping trains from the Central.

Exclusive of through excursions, of which there were quite a number, the maximum number of tickets collected at the four coastal stations—Tynemouth, Cullercoats, Whitley Bay and Monkseaton, to which the fare from Newcastle is the same—during a summer Sunday in 1938 was 46,810, but on the race week Sunday of 1937, a fine Sunday in June, 56,520 tickets were collected. During June, July, and August the number of tickets collected at the four coastal stations averages 30,000 per Sunday.

Large crowds may be expected to travel to the coast stations on bank holidays and on the Wednesday and Thursday of race week. On a fine Whit Monday or August bank holiday the traffic peak is reached and the record number of local tickets collected at the four coastal stations

has so far been 95,274, on Whit Monday, 1933. On such occasions a special programme of train and car working is drawn up in which every available set is brought into use. On the North Tyneside routes a total of about 225 departures from the Central plus 5 from Manors North are provided, and also a special service to and from Walker Gate and the Riverside stations. The return peak is particularly heavy from the coast in the evening, due to it being concentrated over three or four hours.

Electrified Area Emergency Sub-Control

The sub-control is manned for heavy holiday occasions as well as for Sundays in the summer. Its function is to vary the programmed arrangements should this be necessary due to a failure or to an unexpected increase or decrease in traffic. The headquarters of the sub-control is situated at Newcastle Central station, close to the electrified platforms. It consists of two omnibus circuits with a special ring to the control. The inspector in charge of the control can, if he considers it desirable, operate the control from stations other than Newcastle; in fact, he usually goes to Tynemouth in the evenings to supervise the return rush from the coast. This control deals, for example, with any earlier traffic return due to sudden inclement weather. The normal telephonic traffic control, introduced for the electrified area in 1938, is centralised at Newcastle. Another problem in the evening is that trains running from Newcastle *via* Benton fill up at Monkseaton and Whitley Bay; and there is thus no room for passengers at Cullercoats and Tynemouth stations, and as many of these come from the east end of Newcastle and wish to alight at Walker Gate and Heaton, the trains running round the circle in the opposite direction are of no use to them. With a return rush concentrated in perhaps a couple of hours, the special control may therefore order certain down trains *via* Benton to pass Monkseaton and Whitley Bay, or certain down trains *via* Wallsend to reverse at Tynemouth, in order to clear away the crowds from Cullercoats and Tynemouth.

At holiday times the Riverside route is not of much help in enabling traffic density between Percy Main and Manors *via* Wallsend to be lightened, as might be thought by a glance at the map. Many of the trains are eight-car formations, but the Riverside route platforms only take six-car sets. There is less traffic between the stations on this loop and those at the coast than on the main part of the circle, but there is sufficient to prevent any expedient such as reserving, say, two end carriages for through passengers and locking the doors. A practice such as pulling up twice would nullify any gain which might result from using the Riverside line as an alternative route. In any event, the chief problems on national and local holidays are the working on the section where the electrified area converges with the East Coast route, *i.e.*, between Heaton and Central, and the station working at Central, and these are not confined simply to the electrified routes, but are shared with the greatly augmented steam services, many of which are coincident with the north Tyneside electric trains between Heaton South junction and Newcastle.

On summer Sundays and at heavy holiday times the sub-control is manned by pre-arrangement by the District Superintendent's inspector. But it may happen that a failure occurs on a normal day in the electrified area, and at such times the sub-control is switched through to the main Newcastle district control and the latter supervises all emergency arrangements in connection with the failure.

Down electric train between Newcastle Central and Manors, running on the down main line. The connections between the up main and the up and down Tynemouth lines are in the foreground

Up electric train leaving the Gosforth line at Manors, and crossing via the down main on to the up main for the journey to Newcastle Central

If the failure is serious, a district inspector may be sent for and when he arrives he can open out the sub-control at the east end of Newcastle Central station, in which case the main district control can be switched out.

The section between Newcastle Central and Manors is the most heavily occupied section on the N.E. Area of the L.N.E.R., and actually between Newcastle and Manors practically the whole of the electrified service passes over the same tracks as the passenger trains on the E.C. route. In order to reduce the line occupation to a minimum the electric trains are so timed that an outgoing train from the Central passes an incoming train between Central and Manors. An outgoing train for the Benton route usually passes an incoming train from the Benton route, and an outgoing train for the Wallsend route usually passes an incoming train from the Wallsend route. The maximum occupation of the line between Newcastle and Manors and the complicated junction at Manors is therefore limited to about three min. for the two trains, leaving margins for other traffic. However, careful timings of trains have not by themselves proved sufficient to deal with the volume of traffic without delays, and in order to give increased facilities and to expedite the working of the heavy electric and steam passenger and steam freight services between Newcastle and Manors, either-way working was brought into use over two of the four tracks on this section.

Either-Way Working

It was partly to provide amelioration of the operation in this area and to expedite the working of the heavy everyday electric and steam passenger and steam freight services in this area that at the end of 1937 either-way working was brought into operation over two of the four tracks between Central and Manors. Combined with an almost classic arrangement of cross-overs, and the installation of two-aspect colour-light signals, route indicators and track circuiting, details of which are given in the accompanying track diagram, this both-way working has eased operation of all up and down traffic from and to the electric platforms, the main portion of the station, and the freight lines along the south side of the Central station. In 1938 yet a further improvement in the working at the east end of the Central station was gained by the electrification of the South Shields line, which at once halved the number of those engine movements which fouled most lines. The folding plate shows the track layout.

Either-way working is applied to the up and down main lines, the up and down Tynemouth pair still being signalled only for their respective directions. Electric trains from platform 1 have the choice of the down main (*via* 247 and 240); the up main, *via* slips 237 and 241; or the down Tynemouth, *via* slips 237, 241 and 245. The same applies in the up direction, except for the down Tynemouth line, and with the addition of a passage from the up Tynemouth track *via* slips 244, 241 and 237. The routes to and from No. 2 platform are the same on the outer side of slips 235 and 238, as are also those from No. 3 platform, except that the route on to the down main is *via* 241, 158 and 240. Electric train routes to Manors are also available from platforms 4 and 5, except that the only route from No. 5 on to the down main before Manors box fouls the end of No. 4 platform, slip 191. Connections from all four lines are also available to the steam main-line platforms 6, 7, 8, 9 and 10, and No. 1 goods line also has a connection to the up and down main lines. This last can be considered really as available for shunting movements rather than through running, as it involves crossing over the exits to all the passenger platforms, *via* slips 35, 135, 134 and, for the down main, 129.

At the Manors end, trains on the up and down main lines can be crossed over to the Tynemouth lines, *via* slips 12, 13 and 14, and slips 15, 16, 18 and 22 enable trains from Manors North to have a selection of the three lines signalled for up traffic. Finally, slip 21 in Manors East station enables a down main line steam train to regain its proper track if it has been worked out of Central on the up main.

A typical example of the use to which these track layouts are put occurs just before 3.0 p.m. (winter). The down Flying Scotsman is due out of No. 8 platform at 2.54 and runs *via* slips 133, 138, and 139 on to the up main, which it can follow as far as Manors East, where it crosses over slip 21 on to the down main. A minute later, at 2.55, the regular four-car electric train for the coast *via* Wallsend is due out of No. 3 platform and runs on to the down main *via* 241, 158, 240, and thence to the down main platform at Manors East after the Scotsman has cleared the Argyle Street starter, No. 49.

Up South Shields electric train composed of four modernised cars, running on to the High Level bridge from Newcastle Central station

Actually, the quicker acceleration of the electric, coupled with its forward start compared with No. 8 platform, usually means that the Tynemouth train is held for a few seconds at signal 1, near Manors box, until the Scotsman is clear of Manors East. Three minutes after the down electric is due out of No. 3 an up Tynemouth electric from the Wallsend route is due in. This is brought in along the up Tynemouth line, held if necessary at signal 218A until the Scotsman is past, and then goes *via* slips 244 and 241 into No. 3 platform. At the same time a down goods from slip 55 can be passed on to the down Tynemouth and can run through Manors on the same line and cross over at Heaton, or be held at Manors box until the Scotsman and down Tynemouth electric are clear and then moved *via* slips 15 and 21 on to the down main, according to the incidence of the down passenger trains.

Freight Service Complications

Not a little difficulty has been experienced in dovetailing a frequent and accelerated electric service, and also the main-line steam trains, with the intensive freight traffic found in and adjacent to the electrified area on the north bank of the river. No radical changes have been made in the method of freight train operation during recent years, but the improved electric passenger trains, the either-way working between Newcastle and Manors, and the institution of the district control system have all aided punctual working at every point, and thus have assisted towards the elimination of delays.

There is much miscellaneous freight traffic to and from the stations on the Riverside branch, and a large tonnage of coal and coke to the staiths at Whitehill Point and the Albert Edward dock, for the N.E.S. power station at Carville, and to gas works at Willington Quay and North Shields. This traffic comes not only from the west and south of Newcastle but also from the Blyth area, and some of it originates at the collieries along the electrified lines. Marshalling for direct trains to destination was at one time carried out almost entirely at Heaton down yard, but recent alterations have led to some of the marshalling being transferred to Blaydon and to Park Lane (Gateshead). This traffic is worked on to the Riverside branch *via* Byker, but other trains are run from the main line over the south-east curve and *via* Tynemouth on to the east end of the Riverside branch.

Proposals have been considered to use electric locomotives for freight traffic in this area, but this would probably entail some extension of the electrified system without entirely eliminating awkward change-over points from steam to electric traction. A considerable number of railway and private sidings would also have to be electrified. The operation of all or the great majority of freight trains at night is impracticable. A good deal of the general freight is fish from the quays near the river mouth, or stores for ships waiting at various docks. Even some of the mineral traffic—that for ships' bunkers—is often of a similar urgent character, and night working would frequently mean the detention of a ship for an extra day. Indeed, so far as light goods and stores for the Riverside towns are concerned an additional service by means of road vehicles from the Forth goods station at Newcastle has been provided for about 17 years, to supplement the daily deliveries from freight trains. Inbound fish traffic from the North Shields area is also urgent, and is dependent upon the time of arrival of the boats. Fish from this area is worked to Newcastle just after four each afternoon and connections are made with the evening express braked fish and freight trains running south to London and Liverpool.

South Tyneside Operation

For many years a 20-min. service has been provided in each direction between Newcastle and South Shields. Until a few years ago, the trains were almost invariably hauled by the Ex.-N.E.R. Class A 2-4-2 tanks, but for some time before electrification a miscellaneous collection of 0-4-4T, three-cylinder 2-6-2T and 0-6-0 tender locomotives was used. Operation by diesel-electric trains was carefully considered four or five years ago, but in view of the electrified system existing on the north bank of the river, and the imminent modernisation of its equipment, it was decided that conversion of the South Shields line would give superior operating benefits at what would be quite a nominal cost. Regular electric operation was begun on March 14, 1938.

One of the principal advantages of the conversion of

the South Shields line is the improved operation at the east end of Newcastle Central. In going to or coming from the High Level bridge, the South Shields trains used No. 4 platform, owing to a loop being available for standing the shuttle engine, but fouled all the northbound tracks and leads thereto except from platforms 1 to 3. Electrification, by making No. 6 platform usable, has not only halved the number of movements per train over the crossing, but has also produced a quicker clearance of the track at each movement, and has freed the High Level bridge itself and Gateshead station of numerous light engine movements. Since electrification, the South Shields trains have been moved to platforms 5 and 6 at the Central from No. 4, which was used in steam days. This enables No. 4, which is the longest of all the bays at the east end, to be used for north-bound and south-bound (*via* the High Level) steam trains of up to ten coaches.

Between the Central platforms and the High Level bridge is the celebrated "largest railway crossing in the world," which incidentally was renewed last autumn after nearly 15 years' service. All three tracks over the High Level bridge are electrified. The down platform at Gateshead East station is 619 ft. long, but the slips at Gateshead for the middle track over the High Level Bridge are 135 ft. from the Newcastle end of the platform, so that the effective length, if the middle track on the bridge is used, is 484 ft.

The 20-min. service on the South Tyneside line leaves Newcastle at the hour and at 20 min. and 40 min. past, and South Shields at 17, 37 and 57 min. past the hour, arriving at Newcastle at 44, 4 and 24 min. past the hour. Normally there is an interval of only 4 min. between the departure of one train and the arrival of the next at Newcastle, thus involving the minimum amount of occupation of the junction. In order to dovetail with the intensive passenger and freight train traffic at the east end of the Central, certain of the down departures from Newcastle are retarded one to three minutes from the standard time, *e.g.*, the 12.23 p.m. (3 min.), 1.42 p.m. (2 min.) and 4.24 p.m. (4 min.). The terminal time of a train set at Newcastle is 13 to 16 min. and at South Shields 7 min. to 10 min. The four sets employed throughout the day have a round trip time, including all intermediate and terminal stops, of 80 min., the set operating the 11.20 a.m. train from Newcastle, for example, being due out of Newcastle again at 12.40 p.m. Three other six-car sets work two to nine hours during the day. The standard schedule in each direction is 27 min. for the 10 miles 76 chains inclusive of seven intermediate stops, the nominal allowance for each of which is 20 sec. The average schedule speed is thus 24·3 m.p.h. with stops on the average every 1·37 miles, whereas on the North Tyneside circle the end-to-end speed is 23·0 m.p.h. with an average distance between stops of 1·06 miles. In steam days the standard South Shields time was 33 min. down and 34 min. up, so that electrification has brought an acceleration of 18 to 20 per cent. The present service represents a slight increase over steam days, 57 trains a day in each direction as against 55. There is not the same necessity to augment the standard service by expresses during the business hours, the traffic at these times being workmen's rather than residential. Much of it is also between intermediate stations.

On Sundays the South Tyneside line trains leave Newcastle at the hour and half-hour and from South Shields at 15 and 45 min. past the hour. The majority of the trips are worked by two-car sets but these sets have to be increased to four and six cars as the day goes on. On the South Tyneside line the volume of traffic and the variations are not so marked and the problem of summer Sundays is solved mainly by strengthening booked trains and providing a large number of reliefs at times when the volume of traffic is likely to be heavy. These reliefs can be cancelled at short notice in the event of weather conditions or other factors causing the traffic to be light. On the South Tyneside line holiday traffic has not attained the same proportions, but with the southward development of South Shields it is increasing. At holiday times there are about 55 departures from Newcastle to South Shields and a similar number from South Shields to Newcastle. A number of additional relief trains are run at the peak times from Gateshead East to South Shields in the morning and from South Shields to Gateshead East in the evening. These reliefs cater for passengers to and from intermediate stations on the branch but do not enter the congested area on the High Level bridge and at the east end of Newcastle. The provision of reliefs turning round at Gateshead East has really only been practicable since the electrification of the line. These reliefs carry a white circle at each end of the train to distinguish them from the through trains to and from Newcastle. All trains on the South Tyneside line on such occasions are strengthened to 6-car or 8-car sets.

Ice and Snow Regulations

To cope with the ice on the conductor rails, scrapers have always been used, but tests are now being made with Killfrost sprays, as used by the L.P.T.B. Thermometers are provided at selected signal boxes on the North and South Tyneside lines, and at Gosforth car sheds. In cold weather the men in these boxes read the thermometers at 10.30 p.m. and midnight, and if there is more than 3° F. of frost the Newcastle district control calls out the district engineer's staff and the de-frosting van. The advisability of calling out a second van is left for the control to decide later after consulting with the outside staff as to the state of the line. Engines, drivers and guards for the de-frosting van train are called out by the control. If a temperature 3° F. below freezing point is not recorded at 10.30 p.m., a further reading is taken at 2.0 a.m. if the weather is frosty. Even if the de-frosting van is not called out, the district control at the car sheds and the station staffs at Newcastle Central, Manors, Tynemouth, Monkseaton, and South Shields are consulted as regards the desirability of operating the ice scrapers on the trains, particularly on the first morning services over each route. The control then instructs the car sheds at Gosforth as to putting down the scrapers, and the stations arrange as far as they are concerned.

* * * *

The compilation of an article such as this needs a good deal of sympathetic and active co-operation on the part of the railway officers, which on this occasion was given at a time when special traffic was creating extra problems. Therefore our thanks to Mr. W. A. Fiddian, District Superintendent, and to Mr. A. S. Buswell, District Passenger Manager, are more than a formal courtesy; they are a true appreciation of much kindness and unstinted help.

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NOTES AND NEWS

Further Pennsylvania Electrics.—The Pennsylvania Railroad is to acquire a further 20 of the standard GG-1 type 2-Co-Co-2 express electric locomotives for the 11-kV 25-cycle single-phase lines. This order will raise the total of GG-1 locomotives to 109. The other main class of electric locomotive is the 2-Co-2 P5A type, many of which are now geared for freight work.

French Shunting Locomotives.—Ten more heavy C-C type electric hump shunting locomotives of the pattern illustrated and described in the issue of this Supplement for August 18 last, are now being built for the 1,500-volt d.c. lines of the French National Railways.

New Japanese Line.—The new railway proposed between Maibara and Tsuruga in the north-west of Nippon is to be operated electrically according to present intentions of the Japanese Government Railways. The electrification cost is estimated at Y. 7,000,000. There will be heavy grades and a number of tunnels on the line.

34-Year-Old Motor-Coach.—The Birsigtalbahn, a Swiss light railway near Basle, is still operating a double-bogie motor-coach, with bow current collector, which was put into traffic in 1905, and has now covered about 1,100,000 miles. This coach is equipped with four Brown Boveri 750-volt motors with an individual one-hour rating of 50 h.p. at 16·4 m.p.h.

Triple-Armature Motor.—One of the 3,850 h.p. 2-Do-2 express electric locomotives built in 1932 for the ex-Midi Railway, and which have twin-armature motors driving the wheels through quills, is running experimentally with three armatures per motor, which arrangement gives a very convenient system of motor connections.

Tokyo Subway.—The Tokyo electric underground railway has recently been extended southward from Ginza, the terminus since 1933, towards Shinagawa. The present system, open and under construction, extends from Asakusa in the north to Shinagawa in the south, a distance of eight miles, and is operated on the 600-volt d.c. system.

J. L. Burton.—A well-known electric traction engineer with 40 years of experience in railway and tramway transport was lost to us with the death at Hythe on October 4 of Mr. J. L. Burton, at the age of 59. Joining the old Dick Kerr organisation in 1899, he was for a time manager of the Preston works, but subsequently spent a good deal of time abroad, developing electric traction in centres such as Athens and Poland. In his later years he was connected mainly with tramway and trolley-bus developments on behalf of the English Electric Co. Ltd.

French Funicular Railway.—The Lourdes-Pic au Grand-Jer funicular railway was opened in 1900, and since that time has been driven by a Brown Boveri two-phase motor of about 50 kW rated output at 675 r.p.m., 45 cycles, 3,100 volts. The stand-by motor has been used infrequently, as, for example, when the stator of the main motor was rewound. The carrying capacity of the line was increased in 1925 by quickening the running speed of the cars from 3·95 to 4·93 ft. per sec., and the capacity of the cars from 50 to 60 passengers, but no new electrical equipment was installed.

Japanese Electrification.—The Japanese Government Railways now have over 400 route miles of line electrified, all of it on the 1,500-volt d.c. system except the 7-mile Usui-Toge rack section. About 75 per cent. of the electrified mileage is in the Tokyo and Yokohama area, including the Tokyo-Numazu section of the Tokaido main line to Osaka and Kobe. More than 100 private and local railways use electric traction over a route length of 1,600 miles, but many of these systems are little more than tramways. However, the Chichibu Railway, using 1,200 volts d.c., has comparatively big double-bogie locomotives built by the English Electric Co. Ltd. (see issue of this Supplement for March 9, 1934).

Steam Locomotives for Emergency Service.—With the object of reducing the time taken to get up steam in the spare steam locomotives held for emergency service, the Swedish State Railways are making experiments with electric heaters for the boilers. An electric resistance boiler is placed near the locomotive, and pipe connections are made in order to maintain a constant flow of hot water. By this means a pressure of 85 to 110 lb. per sq. in. and a temperature of 150° C. is attained near the firebox comparatively quickly, and the remaining pressure can be attained in about another 15 min. by starting up the coal fire. The electric boiler used has a nominal output of 45 kW at 800 to 1,000 volts and has an overload capacity of 90 kW. It is fitted with an automatic temperature-control system.

New Rectifier Development.—For small- and medium-drop size applications Oerlikon has developed a simple type of rectifier in which forced air cooling is incorporated. The cooling air is forced by a fan through a special cooling space in such a way that a strong rotary flow is produced. The weight and space requirements are appreciably reduced compared with those of a water-cooled unit. A 1,000-kW rectifier of this Oerlikon Cyclon pattern is installed in Zurich for feeding the tramway system, and during the Swiss National Exhibition has also supplied d.c. for the exhibition laboratory. In this example the control cabinet is embodied in the rectifier casing. Similar equipments are being made also by Brown Boveri, and about 50 such rectifiers have been supplied in two years, up to a maximum of 1,600 amp. at 600 volts d.c., *i.e.*, 960 kW. Including the control panel, an installation of this capacity requires only 24 sq. ft. of floor space. For special service grid control can be applied.

Italian Electrification Plans.—It is expected that by the end of 1942 the Italian State Railways will have electrified on the 3,000-volt d.c. system the Domodossola-Milan, Luino-Gallarate, Trento-Verona-Bologna, Cervignano-Venice-Bologna, Ancona-Pescara-Bari-Brindisi-Lecce, Battipaglia-Potenza-Taranto-Brindisi, Messina-Palermo, and Messina-Catania-Syracuse lines. The last two routes mean the introduction of electric traction into Sicily. Secondary lines which are scheduled for conversion in future are Voghera-Piacenza, Lucca-Viareggio, Terontola-Foligno, Caserto-Cancello-Naples, Pisa-Lucca-Pistoia, Pisa-Empoli-Rifredi, Civitavecchia-Orte, and Cancello-Torre Annunziata. The Arona-Domodossola section, now in course of conversion, is to be doubled, and the existing three-phase line between Bordighera and San Remo also is to be given a second track. According to the latest information, test runs on the Milan-Chiasso line are just beginning, whereas the intention last year was to have this line electrified early in 1939. At the beginning of the present year the total estimated coal saving by a.c. and d.c. electrification on the Italian State Railways amounted to about 1,600,000 tons a year, of which 300,000 tons were due to the lines converted during 1938.

Electric Railway Traction

Ignitron Traction Substation

THE latest type of converting equipment for substations, the ignitron, was described (as made by B.T.H.) in the issue of this Supplement for October 14, 1938. At that time the ignitron had been used for traction work only in trolleybus and tramway installations, but in August last a 3,000 kW equipment was installed in heavy electric traction service on the 650-volt d.c. system of the New York Central Railroad. Of Westinghouse manufacture, this equipment is located in a substation at 126th Street, New York city, about five miles from the Grand Central terminal, and it is operated through supervisory control from the existing substation at that terminal. The new substation was erected to meet increasing loads and takes 60-cycle 13·2 kV three-phase current from the New York Edison Company. Rated at 3,000 kW 650 volts, the N.Y.C. ignitron has an overload capacity of 150 per cent. for two hours and 300 per cent. for one minute. Each ignitron unit consists of two groups of six tubes each, the tubes being vacuum-tight and housing an anode, a cathode, and an ignitor; cathode and anode are essentially the same as in a conventional rectifier, but the ignitor is a rod of high resistance, shaped like a pencil point, dipping into the mercury pool. Arc-quenching equipment is provided to drop all current in about one cycle by blocking the ignitors in the event of a short circuit or arc back, and this feature relieves the duty on the breakers opening the short-circuit currents involved. As it was impracticable to instal enough capacity in the 126th street substation to maintain full voltage under any load demand that might occur, a Silverstat regulator has been used to operate on the grids of the excitation thyratron and limit the load on the ignitron to a predetermined overload value.

Long-Distance Electric Journeys

BY the electrification of the 32-mile line between Milan and the Swiss-Italian frontier at Chiasso, it has become possible to travel by electric traction from Basle to Reggio Calabria, in the far south of Italy. There is no possibility of through running by motive power, as the 207 miles of the Swiss Federal Railways—*via* Zurich and Arth-Goldau—are operated on the 15-kV 16⅔-cycle single-phase system, whereas the 871 miles of the Italian State Railways—*via* Milan-Bologna-Rome—are all on the 3,000-volt d.c. system. Although this journey of 1,078 miles is probably the longest possible with any type of through electric service (actually a change of train at Naples is still necessary), the electrification of the Milan-Chiasso section enables a far longer journey to be made by electric traction subject to two or three changes of train. As the Reichsbahn Nuremberg-Berlin main line is now electrified as far as Saalfeld, it is possible to travel from Saalfeld through Nuremberg, Munich, Kufstein, Innsbruck, Buchs, Zurich and the Gotthard line to Chiasso, a distance of 695 miles on the single-phase system, and then straight on over the high-tension d.c. lines of the Italian State Railways to Reggio Calabria, a journey totalling 1,566 miles. Another journey approaching this in length would be from Attnang-Pucheim, in Austria, through Salzburg to Wörgl, where the previous route is joined, giving a total distance to Reggio Calabria of 1,421 miles. On October 28, the day the Milan-Chiasso conversion was opened, the Rogoredo-Voghera line of the Italian State Railways was turned over to d.c. electric traction, and provides an alternative all-electric route between Switzerland, Rome and the south of Italy which has an added interest in that it begins on 3,000-volt d.c. (Chiasso-Milan-Voghera), changes to three-phase (Voghera-Genoa-Viareggio), and then back again to high-tension d.c. for the third section (Viareggio-Rome-Naples-Reggio Calabria). Another long electric journey on the Continent is in Sweden from Malmö through Stockholm to Långsele, a distance of 774 miles, all on the single-phase system, and accomplished with only one change of carriage, at Stockholm. The longest electric journey on the French National Railways is from Paris *via* Bordeaux to Irun, 512 miles.

High Speed Electric Trains

ELECTRIC traction has always been recognised as a means of attaining very high speed on rails, because of the great power it is possible to draw from the contact wire or conductor rail for short periods without damaging the electrical equipment. Despite ends which were little better than square, and the presence of cumbrous overhead current collecting gear, the experimental motor-coaches on the Marienfelde—Zossen line attained 130 m.p.h. 36 years ago, and French express electric locomotives with square ends have attained 112·5 m.p.h. when hauling trains up to 175 tons in weight. Even the Southern Railway multiple-unit trains, the normal work of which is the one-hour London to Brighton expresses, have reached almost 90 m.p.h. But with the advent of streamlining, regular train sets running over ordinary main-line track have almost equalled the Marienfelde—Zossen speeds, which were attained on special track and on a route free from curves. For example, at the end of 1937 one of the Breda streamlined three-car electric train sets on the 3,000-volt d.c. system of the Italian State Railways reached a speed of 201 km.p.h. (125 m.p.h.) between Rome and Naples. More recently, on July 20 last, one of the newer trains to the same general design attained 203 km.p.h. (126 m.p.h.) in the course of a special run between Florence and Milan, some details of which are given on the last page of this Supplement. The motors drive the wheels through a modification of the Bianchi individual axle drive having an intermediate wheel between the pinion and the gear wheel on the axle. At 126 m.p.h. the approximate speed of the armature periphery is 6,150 ft. per min., and of the gear wheel periphery 5,250 ft. per min.

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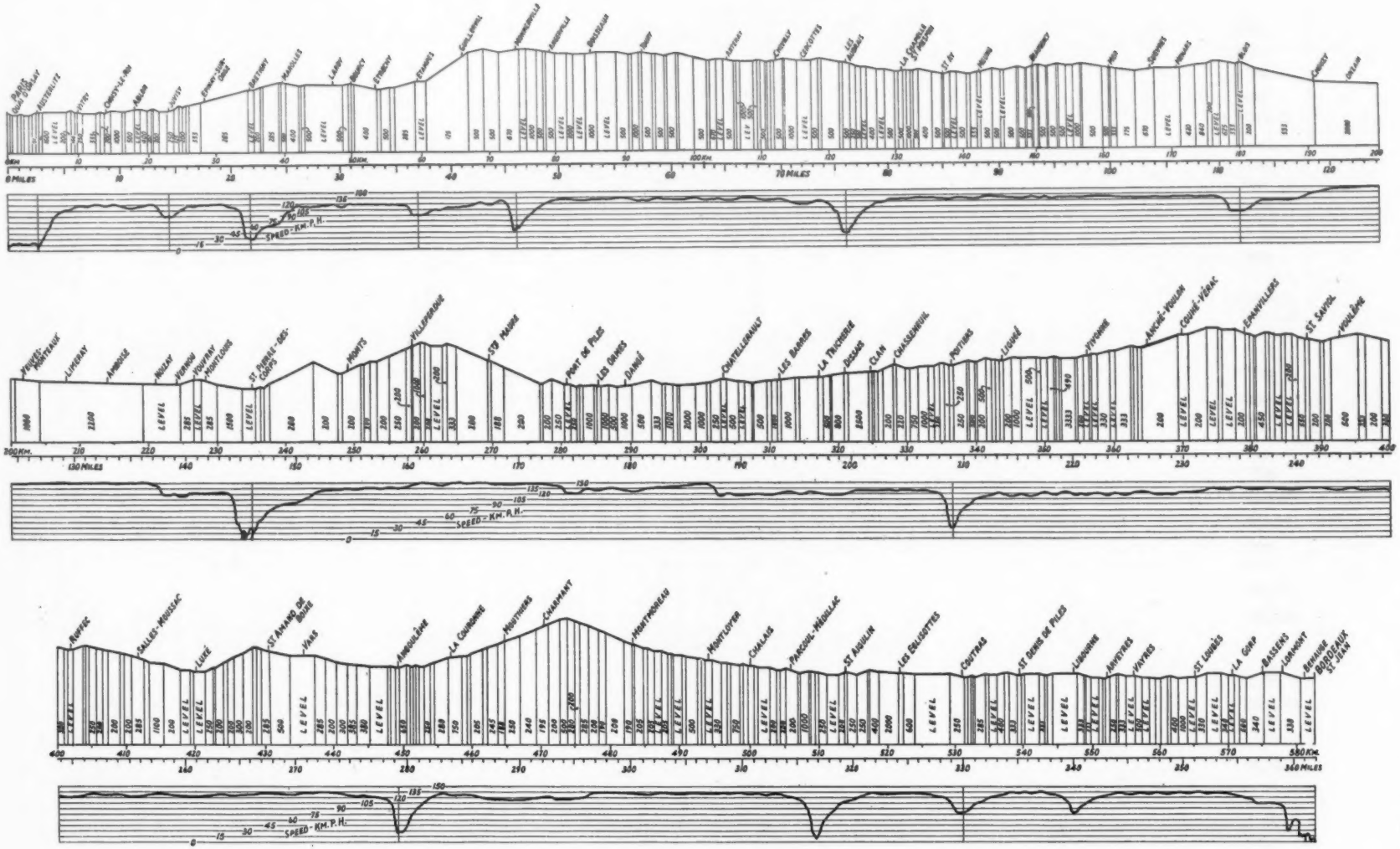
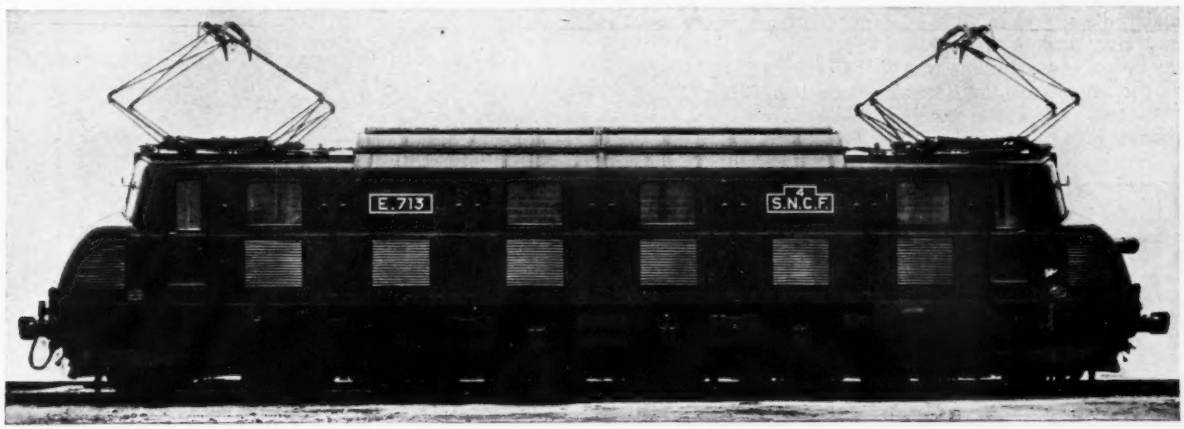


Speed graph in relation to gradient profile of special train No. 10549, *which on March* 20 *last ran from Paris (Austerlitz) to Bordeaux (St. Jean),* 360 *miles, at an average speed of* 73½ *m.p.h. inclusive of stops near St. Pierre des Corps, and signal or service slacks at a dozen other points. The* 441-*tonne train was hauled by locomotive E.*541, *built in* 1938, *and speed was not allowed to exceed* 150 *km.p.h.* (93·7 *m.p.h.). Further particulars of high-speed runs are given on the opposite page*

Express Locomotives and High-Speed Runs on the P.O.-Midi

The French National Railways have 113 express electric locomotives on the Région du Sud-Ouest, and overall speeds up to 73 m.p.h. for 360 miles have been maintained

THE electric stock of the Région du Sud-Ouest of the French National Railways now comprises 659 locomotives at work or on order and 151 motor-coaches in traffic. Of these totals, 328 locomotives and 109 motor-coaches belong to the ex-P.O. section and 331 locomotives and 42 motor-coaches to the ex-Midi section. The P.O. locomotive stock comprises 79 express locomotives of the 2-Do-2 type, 217 double-bogie locomotives, 13 double-bogie shunting locomotives now operating on the metadyne system, and 2 hump shunting C-C type locomotives in traffic and another 10 on order. (See issue of this Supplement for August 18, 1938.) The Midi stud is made up of 24 express locomotives of the 2-Do-2 type, 10 express locomotives of the 2-Co-2 type with vertical motors, and 297 double-bogie locomotives. Within the last 18 months or so the P.O.-section stock has been increased by 24 double-bogie and 14 express 2-Do-2 locomotives, which were ordered nominally in connection with the electrification of the Tours—Bordeaux division. No new motor-coaches were ordered for this conversion. Actually, 24 new express locomotives have been delivered in 1938-39.



One of the latest batch of Schneider electric locomotives for operation between Paris and Bordeaux

Developed from the two Brown Boveri locomotives E.501-502 built in 1925-26, one with and the other without regenerative braking, and which had a one-hour rating of 3,550 h.p. at 40 m.p.h., succeeding batches have had one-hour outputs of 3,650 h.p. at 43 m.p.h., 4,045 to 4,110 h.p. at 45-46 m.p.h., and up to 4,950 h.p. at 60 m.p.h. with shunted field. The electrical equipment of different batches is of Brown Boveri, Alsthom, Oerlikon, and Schneider-Westinghouse manufacture. Those locomotives intended for operation over the Les Aubrais—Vierzon—Brive section, with long 1 in 100 grades, have regenerative braking.

Several high-speed test runs have been made with one or other of the 2-Do-2 locomotives, and speeds up to 185 km.p.h. (112·5 m.p.h.) have been attained with a trailing load of 177 *tonnes* (see issue of this Supplement for March 31 last). Another record was the haulage of a 475-*tonne* train from Juvisy to Les Aubrais, 61¾ miles, in 40 min. pass (at 56 m.p.h.) to stop, the average of 92·5 m.p.h. being with a maximum speed of 98 m.p.h.

On March 20 of this year a special run was made from Paris (Austerlitz) to Bordeaux (St. Jean), in which a nine-car train weighing 441 *tonnes* was hauled over the 580 km. (360 miles) in 4 hr. 54 min. including three momentary stops at St. Pierre des Corps, and service or signal slacks to 56 m.p.h. at Juvisy, 19 m.p.h. at Bretigny, 56 m.p.h. at Etampes, 34 m.p.h. at Monnerville, 25 m.p.h. at Les Aubrais, 55 m.p.h. at Blois, 18 m.p.h. at Poitiers, 18 m.p.h. at Angoulême, 18 m.p.h. at St. Aigulin, and 47 m.p.h. at Coutras and Libourne. The train was scheduled to run the journey non-stop in 5 hr. The locomotive used was No. E.541, one of a batch of eight with Brown Boveri electrical equipment delivered in 1938-39. The remaining 16 of the 24 express engines delivered during 1938-39 are Nos. E.705-712 built by Oerlikon-Batignolles, and Nos. E.713-720 built by Schneider. On the test run of March 20, a speed graph of which accompanies this article, the top speed was not allowed to exceed 150 km.p.h. (93·7 m.p.h.), the normal maximum service speed of 120-130 km.p.h. (75-81 m.p.h.) being raised over the sections from Guillerval to Cercottes, from Chouzy to Vernou-les-Varennes, and from St. Pierre des Corps to Lormont. Except at Poitiers and Angoulême stations, the down track was cleared 20 min. before the booked time of the special. This trial was one of a series undertaken in order to gain information as to the possibility of accelerated services, and to check the safety and comfort of the stock at sustained high speeds.

Although the St. Pierre des Corps to Angoulême section of the St. Pierre—Bordeaux electrification was opened in May, 1938, and the Angoulême—Bordeaux section in January, 1939, the official inauguration did not take place until May 24, 1939, when a special train carrying members of the board of the S.N.C.F., and leading officers, ran from Paris (Austerlitz) to Bordeaux in 5 hr. 12 min. including a one-minute stop at St. Pierre, and without speed exceeding the service limits of 130 km.p.h. (81 m.p.h.) and 120 km.p.h. (75 m.p.h.).

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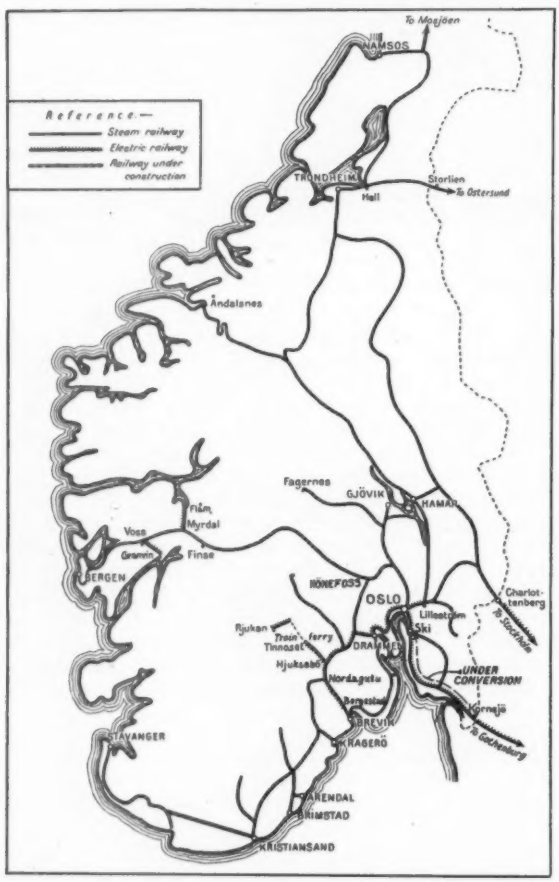
MOTOR-COACH DESIGN IN NORWAY

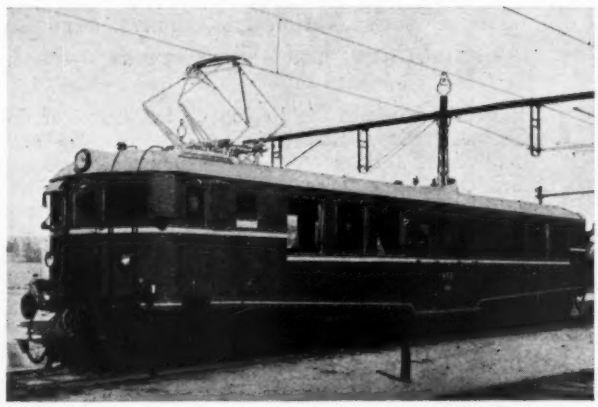
A description of the single-phase equipments and work in suburban service and on a mountainous branch line

NOT until 1931 did the Norwegian State Railways put into traffic their first motor-coaches; before that date all the passenger traffic on the 15-kV 16⅔-cycle single-phase electrified lines was locomotive-hauled, even the Oslo—Drammen suburban trains. Eight years ago, with the object of improving the working on that line and the extension to Kongsberg, two double-bogie motor-coaches were introduced, and proved, naturally, so successful compared with the old double-bogie rod-drive locomotives, that two more vehicles for the same line were ordered in 1932. These cars have two traction motors, each of about 150 h.p. on the one-hour rating.

While the Voss-Eide line was under construction a decision was made to work it electrically, by motor-coaches and trailers, and in 1933 an order for three motor-coaches and five trailers was passed, and this stock came into operation when the line was opened on April 1, 1935. But as the grades are very steep, as much as 1 in 22 uncompensated, each motor-coach is provided with four traction motors with an individual one-hour rating of 116 kW, and



Sketch map showing State electrified lines in Norway, except the mineral line from Sweden to the Atlantic in the far north



620 h.p. motor-coach operating on the suburban services from Oslo to Drammen and Ski

the double-bogie trailers are of a special light weight construction embodying a large amount of aluminium alloy in the framing and in the body panelling.

Suburban Stock

The development of the Oslo suburban traffic, both by the increase in the number of passengers carried in the Drammen direction and by the electrification of the Oslo—Ski line, necessitated further additions to the motive power, and four more four-motor cars were ordered in 1935 and another six in 1936-37. Although the Oslo suburban coaches are not as light as those on the Voss—Eide branch, nevertheless they form an improvement in this direction over the four original suburban motor-coaches of 1931-32, and the ten latest vehicles weigh 41·75 *tonnes* against the 35·5 *tonnes* of the Voss—Eide stock with welded steel bogie frames, welded steel carriage framing, and aluminium panelling and details. The Norwegian Brown Boveri Company supplied the electrical equipment for all of these motor-coaches and for seven additional motor-coaches ordered for delivery in 1939 and 1940.

The suburban motor-coaches seat 68 passengers and have a lavatory and a small amount of luggage space. The top speed in normal service is 70 km.p.h. (43½ m.p.h.) and two or three trailers are hauled, the outer vehicle usually being a driving trailer. The Voss—Eide motor-coaches have 80 seats, baggage and postal compartments, and lavatories. In view of the steep grades, a top speed of only 50 km.p.h. (31 m.p.h.) is permitted, and hand, vacuum, and electric braking systems are incorporated. Both types of motor-coach have the same diameter wheels, *viz.*, 810 mm. (32 in.), but to suit the different maximum speeds the gear ratio from motor to axle in the suburban stock is 1 : 4·27, whereas in the Voss—Eide vehicles it is 1 : 5·54.

On each bogie are two nose-suspended series-wound self-ventilated traction motors having resilient gear wheels. The one-hour rating of each motor is 116 kW at 1,160 r.p.m., and the continuous rating 95 kW at 1,330 r.p.m. The one-hour figures correspond to a motor voltage of 255 and to a track speed of 42 km.p.h. (26 m.p.h.). The two motors on each bogie are permanently coupled in series. This aggregate motor power of 620 h.p. per coach on the one-hour rating is sufficient to enable the Voss—Eide cars to maintain a speed of 32 km.p.h. (20 m.p.h.)

up the 1 in 22 uncompensated grades with a total train weight of 106 *tonnes*. In the Oslo suburban services the train weight per motor-coach rarely exceeds 120 *tonnes*.

Although the electrical equipments of both motor-coach types are the same as regards traction motors, there are considerable differences otherwise. The Voss—Eide stock, like the four Oslo suburban motor-coaches of 1931-32, has a.c. electromagnetic contactor control, an a.c. lighting installation, separate electric radiators, and electric braking equipment. Electric braking is not fitted to any of the suburban stock, and the latest vehicles of this type have cam-type controllers, d.c. lighting, and electric air-heating devices.

On the Voss—Eide section electric braking is applied only to the motor-coaches, and as a relatively moderate braking force is required to hold the car and any trailers to a steady speed when descending the maximum gradient, the adhesion load on three out of the four driving axles is enough. Therefore, only three traction motors are used for braking, and these are excited by the fourth. During braking this fourth motor is itself excited in closely regulated steps from the generator of a small braking converter set. For the sake of simplicity, independence from the contact wire has not been attempted. As the principal purpose of the electric braking system was to hold the train to a steady speed when running downhill, it was unnecessary to lower the braking speed range to the neighbourhood of zero, and this has saved complication and a high consumption of excitation current. The lowest electric braking speed is 20 km.p.h. (12½ m.p.h.). There is a special drum in each driving position to adjust the braking excitation, and this is embodied in the main driving controller.

The transformer on the Voss—Eide coaches is of the usual oil-immersed type with cooling pockets, and is suspended below the car body. It has a continuous rating of 375 kVA for the traction supply, 25 kVA for auxiliary services, and 60 kW for heating. Line current for both types of motor-coaches is collected by a single pantograph.

A multiple-unit nine-notch electromagnetic control is fitted. The trains on the Voss—Eide line have continuous vacuum brake equipment, and there is an exhauster on each power vehicle, driven by a single-phase series-wound motor. A second auxiliary motor of the same design drives a small compressor providing air for raising the pantograph, and actuating the reverser, brake change-over switch, whistle, and sand-sprayer. Heating of the interior of the coaches is by means of ordinary electric radiators connected to a tap on the tapping transformer at a tension of about 1,000 volts. Connected to the same tap is the high-voltage winding of a small transformer which lowers the voltage to that required for lighting at the line periodicity of 16⅔ cycles, *viz.*, 12 volts.

To attain maximum reliability despite the considerable fluctuations in line voltage found in the electrified suburban areas, a cam type of multiple-unit control was chosen, and the number of running notches increased to 10. The camshaft of the controller is rotated by mechanism driven by an electric motor, and the control is at 32 volts d.c. The current for train lighting comes from the same source as the control supply, *viz.*, a generator and storage battery connected in parallel. The generator is driven from one of the car axles through a gear and cardan shaft. For the car heating, current up to 30 kW is passed through a heating resistance suspended below the floor, and the heat is transmitted to a current of air maintained by a fan and blown into the various saloons. The heating load can be reduced in a number of steps down to 2·5 kW, but under all loads the fan runs continuously and ensures a regular and even renewal of air. With the heating entirely cut off, the fan acts simply as a force-ventilator, keeping the interior of the motor-coach cool in summer. The maximum air delivery is 20 cu. m. a minute (700 cu. ft. per min.). The Oslo suburban motor-coaches are braked on the compressed air system.

Left: One of the three special 35-ton 620 h.p. motor-coaches used on the Voss-Eide, or Granvin, branch of the Norwegian State Railways

Below: Interior of one of the Voss-Eide motor-coaches

RECTIFIER INSTALLATIONS IN BELGIUM

MORE than half of the receipts of the Belgian National Light Railways are obtained from the routes which are electrified, but which total only about 900 route miles out of the whole route length of 2,990 miles. The electrification is on the 600-volt d.c. system with overhead current collection, and many of the routes are closely akin to tramways in their characteristics.

Glass-bulb rectifier sets are now being used for new substations, and among such substations erected within the last two years or so are those at Assche and Alost, both of which are equipped with Asea rectifiers with Hewittic bulbs. The standard bulb size is 213 kW (350 amp. 610 volts d.c.). Assche substation has one 213-kW set and one double-bulb set of 426 kW, whereas Alost has two 213-kW equipments. The transformers are connected to a 10·6-kV network, and the interphase transformer is housed in the main tank. For the connection of the secondary winding of the transformer to the rectifiers, non-reinforced single-strand cable is used.

Arrangement of Glass-Bulb Equipment

At each substation the two sets operate in parallel on the same three-phase supply. The current and voltage characteristics are so adapted that although they may be of different sizes the load is distributed in proportion to the outputs of the sets. Parallel operation is also possible if one bulb of a two-bulb bank is disconnected, although in this case a small unbalanced load will arise. At Assche substation the transformer for the 426-kW double-bulb set has its secondary winding divided into parallel parts.

The measured efficiency of the double-bulb 426-kW set is 94·3 per cent. at $\frac{1}{4}$ load, 96 per cent. at $\frac{1}{2}$ load, 95·8 per cent. at $\frac{3}{4}$ load, 95 per cent. at full load, 93·8 per cent. at $\frac{5}{4}$ load, and 91·7 per cent. at $\frac{6}{4}$ load, including all losses of the set. When a bulb is to be disconnected from the transformer secondary, and the casing is not live, the anode fuses can be screwed out; they are easily accessible at the front of the casing, and the anode conductors are taken from the transformer directly to the fuses, so that the casing is entirely without current when the fuse protection is absent. But in the cathode conductor a disconnecting switch is inserted, and is located at the bottom of the cubicle, at the rear.

The rectifier plants are arranged for unattended operation, and are equipped with time switches for the connection and disconnection of one of the sets. The stand-by set is automatically brought into operation when the load on the working set approaches the full value, and is disconnected when the load has fallen. The difference between the load on connection and disconnection is large enough to prevent unnecessary operations. The stand-by set is also arranged to take over the working automatically in the event of failure of the main set.

Each substation has two outgoing d.c. lines provided with air breakers, which are operated by test circuits containing a voltage relay which senses the resistance in the line and prevents connecting it on a short circuit. The substation equipment also includes fault indication and signal emission and blocking apparatus, which are mounted together with the control apparatus and instruments in special cubicles with mimic busbar diagrams on the front.

* * * *

The Belgian National Light Railways (Soc. Nat. des Ch. de fer Vicinaux) at the end of 1938 operated electrically 1,454 route km. out of a system total of 4,808 km. Yet the electric services carried 167,601,357 passengers during 1938 out of a total of 193,573 carried by all forms of traction including road buses. Of the total receipts earned by the electric services, 96·8 per cent. came from passenger traffic, whereas on the lines operated by steam traction and railcars the receipts were evenly divided between passenger and freight traffics. The electric rolling stock comprises 1,041 motor-coaches, 806 trailers, 27 motor baggage and goods cars, one electric locomotive and nine miscellaneous vehicles. During 1938 a total of 45 new bogie motor-coaches was delivered.

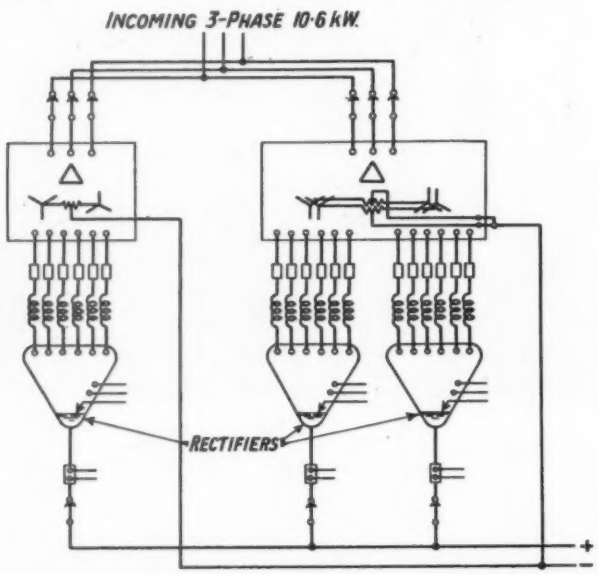


Diagram of rectifier circuits in Assche substation. The transformers have an interphase connection

Electric Traction in Gold Mines

Many of the mines on the Rand use electric trolley locomotives for surface haulage, and some of them for haulage on the main drives also, but trolley locomotives with reel and cable are popular, as are battery locomotives. Battery locomotives are generally used for gathering service, taking the ore from the working faces to tippets at the junction with the main drive, where the ore is transferred to larger trucks for haulage to the foot of the shaft. Recharging is done at the end of each shift in special underground charging stations. General locomotive maintenance is carried out underground, and sometimes heavy overhauls, too. When the battery is to be taken off, the locomotive runs under its own power between lifting rails, which are raised by jacks to lift the battery off the frame; a wandering lead is then plugged into the battery and the locomotive, and then the locomotive runs slowly out from between the lifting rails under its own power, for inspection and overhaul. A large number of these locomotives at work on the Rand are equipped with Exide-Ironclad batteries, which have given very reliable service, even at depths up to 6,000 ft. below the surface. Some of the mines have as many as 50 battery locomotives in service.

TRACTION MOTOR GEARS

A correspondent discusses the materials and the basic principles of design

EXCEPT for the highest powers and speeds the great majority of electric railway vehicles are driven by motors of the nose-suspended tramway type. Space between the wheels being limited, it is usual for the motor torque to be transmitted to the axles through single spur gearing, but where space allows twin gears are to be preferred in order to eliminate torsional effects, although it is not so easy to inspect the commutators and brush gear. This is rarely possible on the standard gauge, but the slight extra space given by a gauge of 5 ft. enables this to be done, as it is in the U.S.S.R.

The ratio of the gear reduction is determined by the maximum speed of the vehicle, the size of the wheel, and the motor speed. As far as railway conditions are concerned it is often difficult to obtain the required clearance between the rail and the bottom of the gear case, in this country usually a minimum of 6 in. with new tyres.

Armature and Gear Speeds

In addition to the rail clearance the peripheral speed of the gearing may prove a limiting factor. For economical motor design the armature and the gears should both reach their safe maximum speeds at about the same time. The usually accepted figures are 7,500 ft. per min. for the former and, when grease lubrication is employed, 4,000 ft. per min. for the latter. In large electric locomotives employing individual axle drives forced lubrication is adopted and gear rim speeds of over 6,000 ft. per min. obtain.

Consider a multiple-unit electric train with wheels having a diameter when new of 3 ft. 6 in. driven by axle-hung motors, a maximum speed of 60 m.p.h., and a gear reduction of 2·81 : 1 on 20-in. centres. The pitch circles of pinion and wheels are 10·5 in. and 29·5 in., respectively. With wheels worn to 3 ft. 4 in. dia. the r.p.m. at 60 m.p.h. will be 504 and the motor revs. 1,418. The peripheral speed of the gears is 3,900 ft. per min., and that of the armature—19·5 in. in diam.—7,250 ft. per min. It is not always possible to obtain such good figures as provided by this actual example.

Tooth Capacities

Railway traction motor gears usually have a diametral pitch of 2, but this varies from 2½ in the smaller to 1¾ in the larger sizes. The form of tooth employed is the 20° involute, which in addition to manufacturing advantages is the strongest of the normal profiles and maintains its accuracy of rolling contact when the centres are slightly displaced. In some instances Maag gears have been used with success. By the use of a special profile these gears can carry a heavier load than the usual type, and it is claimed that peripheral velocities of 10,000 ft. per min. are practicable.

The gears and wheels mentioned above as typical examples are fitted to motors which give a tractive effort at the wheel rims under normal conditions of 6,500 lb. up to 5 m.p.h. At the pitch circle of the gears the force is

$$\frac{6{,}500 \times 21}{14{\cdot}75} = 9{,}250 \text{ lb.}$$

and the power transmitted at 5 m.p.h.

$$= \frac{9{,}250 \text{ lb.} \times 310 \text{ ft. per min.}}{33{,}000}$$

$$= 87 \text{ h.p.}$$

According to Bostock and Bramley's formulæ (as published in " Gears and Gearing " by Bramley-Moore), a pinion having the dimensions given above, and a face width of 6 in., is suitable for transmitting 85 h.p. To slip the road wheels with a coefficient of friction of 0·33 between wheel and rail requires a tractive effort at the wheel rims of 7,500 lb., the adhesion weight being 11·25 tons. The motors are capable of delivering this tractive effort so that the maximum transmitted h.p. at 5 m.p.h. becomes 101. Of course such formulæ as that used above allow an adequate factor of safety.

Power Transmission at Speed

At high speeds the power transmitted is far below the value with which the gears are capable of dealing. At 60 m.p.h. and with new track wheels, the above motor gives 665 lb. tractive effort at the wheel rim, which becomes $\frac{21 \times 655 \times 3{,}705}{14{\cdot}75 \times 33{,}000} = 93{\cdot}5$ h.p. transmitted by the gears.

Bostock & Bramley's formulæ give 440 h.p. as the permissible value.

For purposes of stress calculation the pinion is taken as having 1·45 teeth in contact. The pressure per tooth is thus $\frac{9{,}250}{1{\cdot}45} = 6{,}400$ lb. With a diametral pitch of 2 the total tooth depth is 1·58 in., the bending stress at the

MATERIALS USED FOR TRACTION MOTOR GEARWHEELS AND PINIONS

Pinions.—Cut from solid block of air-hardened nickel-chrome steel having an ultimate strength of 100 tons per sq. in. with a yield point of 84–85 tons per sq. in.

Analysis—

	Per cent.
Nickel	4·0
Chromium	1·5
Carbon	0·4
Sulphur	0·03*
Phosphorus	0·03*
Manganese	0·4
Silicon	0·2
Elongation on 2 in.	10·0†
	Ft.-lb.
Izod impact value	10
Brinell hardness no.	444

* Max. † Min.

Gearwheels.—Cast in one piece of nickel-chrome steel having an ultimate tensile strength of 55–65 tons per sq. in., and a yield point of 44–50 tons per sq. in.

Analysis—

	Per cent.
Nickel	3·25
Chromium	0·9
Carbon	0·35
Sulphur	0·03*
Phosphorus	0·03*
Manganese	0·55
Silicon	0·2
Elongation in 2 in.	18·0†
	Ft.-lb.
Izod impact value	35
Brinell hardness no.	255–293

* Max. † Min.

Gearwheels. — Nickel - chrome oil-quenched steel; ultimate strength 70 tons per sq. in., yield point 55 tons per sq. in.

Analysis—

	Per cent.
Nickel	3·6
Chromium	0·8
Carbon	0·13
Sulphur	0·04*
Phosphorus	0·03*
Manganese	0·40
Silicon	0·16
Elongation in 2 in.	14·0†
Reduction in area	50
	Ft.-lb.
Izod impact value	35

* Max. † Min.

Gearwheels. — Nickel - chrome-molybdenum steel; ultimate strength 58–60 tons per sq. in., yield point 46 tons per sq. in.

Analysis—

	Per cent.
Nickel	3·6
Chromium	0·9
Molybdenum	0·3
Carbon	0·32
Sulphur	0·02
Phosphorus	0·02
Manganese	0·68
Elongation in 2 in.	21·0*
Reduction in area	54·0
	Ft.-lb
Izod impact value	64

* Min.

root (taking the load as being applied at the tip) being obtained from :—

$$S = \frac{6\,Pl}{h^2}.$$

Where S = Maximum bending stress.
P = Load per in. of face length.
l = Depth of tooth.
h = Thickness of tooth at root.

Referred to the case under consideration the figures become

$$S = \frac{6 \times \frac{6{,}400}{6} \times 1{\cdot}58}{2{\cdot}46} = 4{,}125 \text{ lb. per sq. in.}$$

Due to inaccuracies in the teeth from machining conditions, and to vibrations in the gear system, the pressures between the teeth may be much greater than the value calculated from the torque. It was to allow for this additional load that the well-known power-transmission formulæ, such as the Lewis and the Bostock & Bramley, were evolved.

Pinion and Gearwheel Materials

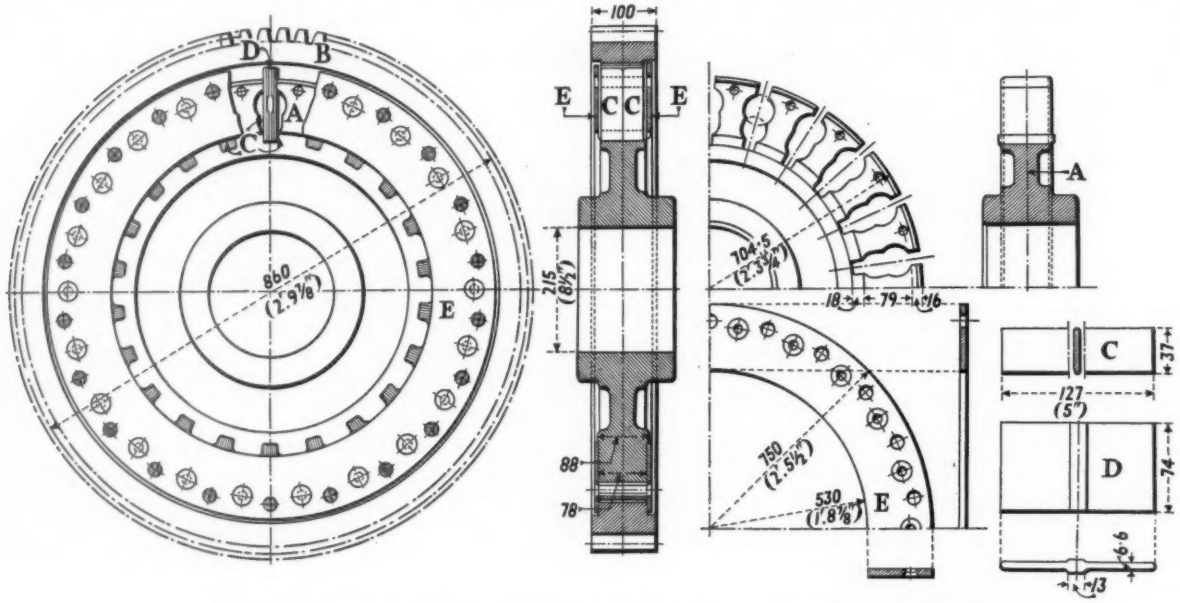
For small work, the material of which the gears are made is a forged steel containing 1 or 2 per cent. of nickel and having an ultimate strength of some 40 tons per sq. in. Case-hardening steels with a carbon content up to 0·4 per cent. are occasionally used in railway work. These steels have a greater wear resistance than alloy steels but are lacking in other respects. Even a non-casehardening steel having a high carbon content is better, strength for strength, than a nickel steel from the wear point of view.

A material with greatly enhanced strength becomes necessary for the more severe conditions of large powers, and high-grade alloy steels are extensively used. They have a much greater ductility and resistance to shock than the plain carbon steels, but have not necessarily a greater wear-resisting capacity. Representative specifications are given in the attached table.

If a small amount of molybdenum—say 0·2 to 0·5 per cent.—is added to the above steel the brittleness is decreased and a higher impact value obtained. This introduction of molybdenum has probably been one of the greatest factors in improving the materials of gearwheels and pinions as it has in materials for other purposes.

Pinion and Wheel Mounting

The pinions are keyed to the armature shaft and secured by a nut, the bore being tapered at a rate of from 1 in 6 to 1 in 10. Further, they are boiled just before putting on the shaft and have thus the additional security of a small amount of shrinkage, while the temperature is not sufficient to affect the temper of the steel. In the ordinary way the gearwheels are forced on to the axle with an hydraulic pressure of 10 to 15 tons per in. of diameter of gearwheel seat. Keys are not always fitted, and judging by results in service they do not appear to be necessary. The gears are cut before being pressed on the axle. There are a number of instances of the use of gearwheels forged in two pieces and secured to the track-wheel instead of the axle, but the advantages of such an arrangement are local, and peculiar to the particular lay-out.



Arrangement and details of flexible gearwheel, which, in the form of twin gears is used to transmit the torque of a 580 h.p. motor in the U.S.S.R. locomotives

The attached illustration shows a twin-gear arrangement as used on the Co-Co locomotives of the U.S.S.R. The centre of the gearwheel is pressed on to the axle with a force of 95 to 125 tons. The gearwheel centre is of cast steel and has on its outside rim 22 openings into which are inserted the bottom ends of short laminated springs. The toothed rim of the gearwheel is made of steel with a carbon content of 0·55 to 0·65 per cent. and an ultimate tensile strength of 50 to 52 tons per sq. in. It is heat-treated to give a Brinell hardness number of 320 to 360. The rim has 86 teeth and these mesh with the 23 teeth of the pinions. On the inside of the toothed rim of the gearwheel are 22 notches corresponding to those of the centre and which carry the outer ends of the laminated springs. Each spring unit comprises eight blades with spaces between them and which when assembled have a thickness of 21 mm. A tractive effort of 8,920 lb. is exerted at the treads of 52-in. wheels through a pair of these gears on the one-hour rate.

ITALIAN ELECTRIFICATION DATA

Notes on the equipment of the Rome–Leghorn and Milan–Ancona lines

THE Rome—Leghorn and Milan—Ancona lines, which were turned over to 3,000-volt d.c. electric traction in November, 1938 (see issue of this Supplement for December 9, 1938), brought the electrified route mileage of the Italian State Railways up to 2,953. When the Rome—Leghorn line was electrified the continuation from Leghorn to Viareggio, 25 miles, was changed from the old 3,700-volt three-phase current to the new standard high-tension d.c. The Rome—Leghorn section, including the Fiumcino branch, totals 203 miles, of which 196 miles are double track. The Milan—Ancona route, including the Salsomaggiore branch and the Fidenza—Fornovo—Parma triangle, totals 299 route miles, of which 263 miles are double track.

For the Rome—Leghorn conversion, a three-phase 135 kV e.h.t. network, 328 miles long, has been constructed. The line is fed by nine rectifier substations, each containing two steel tank rectifiers with an individual continuous capacity of 2,000 kW; the overload rating is 6,000 kW momentarily, giving a total capacity for the line of 36,000 kW continuous, and 108,000 kW for the peak load. On the Milan—Ancona line there are 11 substations of a similar type taking current from an e.h.t. network which has a length of 647 miles. One new rectifier substation has been erected on the Leghorn—Viareggio line. The e.h.t. lines which have been erected in conjunction with these two railway electrification schemes, although intended primarily for railway purposes, actually link up with the existing railway and industrial transmission systems belonging to four private companies, and also the new steam-geyser power station at Larderello, near Pisa. In the construction of the 975 miles of the recent e.h.t. extensions, 6,129 pylons, 330,000 insulators, and about 2,920 miles of conductors have been used. The State Railways now possess the most extensive e.h.t. system in Italy, aggregating about 4,970 miles, much of it at 135 kV.

For the 21 substations of the two electrification extenions completed in 1938 there are 44 buildings, 21 of which house the rectifiers and converting machinery and 23 the ancillary equipment. A further 37 buildings have been erected to accommodate the substation staffs and their families. At each substation arrangements have been made for coupling up one of the mobile converting plants, to which are allocated the task of replacing a rectifier in case of failure or overhaul. The extensive use of these mobile plants enables the fixed equipment to be kept to the minimum.

Notes and News

An Edison Anniversary.—Fifty years ago, in September, 1889, Thomas A. Edison introduced his first zinc copper-oxide primary cells for commercial purposes. The principle had been invented in 1883 by Lelande and Chaperon, but it was Edison's improvements which made the cells a practical proposition.

100 M.P.H. Multiple-Unit Trains.—The receivers of the Chicago, North Shore & Milwaukee Railroad are seeking permission to buy two four-car air-conditioned multiple-unit trains suited to a top speed of 100 m.p.h. Subject to federal approval, an order is to be placed with the St. Louis Car Company at a price of $299,000. The North Shore operates 70 m.p.h. start-to-stop schedules with square-ended multiple-unit trains. References to this line will be found in the issues of this Supplement for November 11, 1938. and January 11, 1935.

Brünig Line Rolling Stock.—In connection with the electrification of the Swiss Federal Railways metre-gauge line from Lucerne to Interlaken (which was fully described, with a map, in THE RAILWAY GAZETTE for June 17, 1938), an order has been placed with the Swiss Locomotive & Machine Works, Winterthur, and Brown, Boveri & Co., Baden, for 16 motor-coaches for mixed adhesion and rack working. They are to include space for luggage and parcels, but no passenger accommodation. The total cost of the contract is fr. 3,864,000.

Italian Openings.—On October 28, the 32-mile line from Milan to Chiasso, on the Swiss frontier, was turned over to 3,000-volt d.c. electric traction, and also on the same day the 38-mile line from Rogoredo junction, south of Milan, to Voghera, where the three-phase system is joined. Yet another electric opening on the same day was from Falconara (near Ancona) to Orte, on the Florence-Rome main line, a distance of 126½ miles.

Further Swiss Electrification.—The Vevey-Chexbres Railway, a standard-gauge line 7·8 km. in length, is to be electrified on the 15 kV-single-phase system. It was opened in 1904 and connects Vevey with the Lausanne-Berne line at Puidoux-Chexbres station; it is leased and worked by the Federal Railways. As both terminals are on standard electrified lines, and there is a steep gradient throughout with a maximum inclination of 3·8 per cent., electrification should be an economical proposition.

Representations have been made by the local interests concerned, for an early conversion of the Neuchâtel-Pontarlier and Stein-Winterthur lines. These routes carry comparatively light traffic, but the former has numerous tunnels and a gradient of about 2 per cent. throughout most of its length. The sections actually to be electrified would be Auvernier-Pontarlier, Stein-Koblenz-Eglisau, and Bülach-Winterthur.

Italian High-Speed Run.—On July 20 last a test run with one of the State Railway's Breda three-car streamlined electric trains between Florence and Milan gave some remarkable results. The overall distance of 196 miles was covered in 115 min. at an average speed of 102¼ m.p.h., the final 136 miles from Bologna (pass at 50 m.p.h.) to Milan occupying only 77 min., equivalent to an average of 106½ m.p.h. More striking still was the fact that the heavily-graded Appenine section (the Direttissima), 60 miles in length, between Florence and Bologna was completed in 38 min., at an average speed of 95 m.p.h. The highest speed attained was 203 km.p.h. (126 m.p.h.), but a pass to pass average of 175·8 km.p.h. (109·2 m.p.h.) was maintained over the 124 miles from Lavino (north of Bologna) to Rogoredo (south of Milan). Sr. Benni, the Minister of Communications, and nearly 100 guests travelled on the train.

XUM

TWO NEW DRUMM BATTERY TRAINS

One of the new 135-seater twin-car articulated 400 h.p. Drumm battery trains for the 5 ft. 3 in. gauge Great Southern Railways suburban line running south from Dublin

TWO new Drumm battery trains have been built at the Inchicore works of the Great Southern Railways, and were put into traffic between Dublin (Harcourt Street) and Bray just before the end of September. They are of the twin-car articulated type with a length of about 120 ft., and each is propelled by two 500-volt 200-h.p. traction motors mounted on the central articulation bogie. There is a driving compartment at each end, and multiple-unit operation is possible. In general, the electrical equipment is the same as that of the two trains which have been at work some years, and include regenerative braking and electro-pneumatic control. There are two equipment compartments, one housing the switchgear and compressor, and the other the exhauster and the motor-generator set for the lighting. The side-slung battery casings are ventilated by means of motor-driven fans. The carriage portion is much improved compared with that of the earlier stock. The floors are of steel sheets covered with granulated cork, and the sides, ends, and roofs are of steel plates secured to teak pillars. The colour scheme of the first class accommodation is blue, and the saloons are finished in sapene mahogany; in the third class saloons the colour scheme is brown and the finish is in Rexine. All seats (36 first class and 99 third class) have chromium-plated tubular frames, and the windows and other fittings are also chromium-plated. Since these two new sets went into traffic, all the normal passenger trains between Harcourt Street and Bray (the ex-Dublin & South Eastern Railway's line) are booked to be operated by battery traction.

LETTER TO THE EDITOR

Traction Motor Ratings

Fassett House,
Great Baddow
September 28

TO THE EDITOR OF THE ELECTRIC TRACTION SUPPLEMENT

SIR,—Mr. Gerald F. Smith's letter in your September 15 issue raises some interesting points. In general, with standard-type locomotives, especially d.c. locomotives, it is only possible to utilise either the full one-hour rating output, or even the continuous output, during periods of acceleration, except perhaps on very severe gradients. On the locomotive in question, however, mainly due to the fact that it is a single-phase locomotive using variable voltage for the motors, both the continuous and the one-hour rating can be exceeded with various train weights on the particular gradient in question, namely 2·5 per cent. Presumably, the motorman would be instructed, when ascending this particular gradient with these train weights, to use one of the lower voltage transformer tappings for the traction motors, although one would imagine under actual service conditions if the train happened to be behind schedule, the motorman would naturally—knowing that he had the power available—use a higher motor voltage.

Presumably, the figures quoted in the *Electric Traction Supplement* for July 21, indicate that the locomotive would be able to haul these train weights on these grades for an indefinite period, this output only being exceeded during accelerating periods. This raises the question which has been a controversial point for some time past now amongst traction engineers, namely, what should be the relation between the r.m.s. current used by the locomotive or motor-coach in normal service, and the continuous rating current of the traction motors. To many people it has appeared quite misleading that a traction motor having a continuous rating of say 500 amp. should not be allowed to be used on a service where the r.m.s. current exceeded say 350 amp., *i.e.*, giving a ratio of 65 per cent. between service r.m.s. amp. and the continuous amp.

As is well known, the temperature rise under existing standards on the continuous-rating current on the test bed is 105° C. and owing to the ratio adopted between the service r.m.s. current and the continuous current, the temperature rise of the traction motors under service conditions rarely exceeds 65° C.

Bearing in mind the improvements that have been made during recent years in methods of insulation and other manufacturing details, it is time that this ratio should be considerably increased. Then there would be no need to alter the existing standards for temperature rise of traction motors on the test-bed for the continuous and one-hour rating currents, *i.e.*, motors for given sizes and speed would still have the same nominal ratings, but in general for a given service the traction motors would be less.

Experiments are to be carried out on an important transport undertaking to determine how near the service r.m.s. current can be to the continuous current of the motor. Tests already carried out by the writer on a foreign railway indicate that this ratio can be considerably increased. On the locomotive in question it is interesting to note that at the top speed of 68 m.p.h. it is not possible to utilise more than about 60 per cent. of the continuous rating output, and this percentage is higher than many other locomotives of fairly recent manufacture.

RAILWAY ENGINEER

Electric Railway Traction

Electrified Systems and Air Raids

SHORT of direct hits on generating plants, it is probable that damage done to electrified railway systems by air raids will not be as great as most of us have at one time or another believed. By providing suitable supplies of standard materials or unit assemblies, and an adequate force of electricians and repair men, restoration of service should take no longer than with an ordinary steam-worked line, whether the electrification be high-tension with overhead current collection or low-voltage fed through conductor rails. In densely-trafficked electrified areas the signalling system is usually a good deal more complicated than the traction distribution, and probably it would be signals which would retard the restoration of a full service. Destruction of a substation might be a serious matter, and although it should not delay the resumption of the train service longer than the repair of track and current distribution, the speed and service of trains might be severely restricted if the sub had to be cut out and its section divided between the subs on each side. In cases of this nature the mobile substation, as used for some years in Italy and Sweden, is of great value. It can easily be run to the spot and temporary connections made to the source of supply and to the catenary system or conductor rail. If a siding is available at the damaged sub normal operating conditions might be restored in a few hours, but at a number of locations it would be necessary to provide a switch and a short length of siding if single-line working was to be avoided. The mobile substations in Italy and Sweden (see issue of this Supplement for March 5, 1937) are special permanent vehicles, but if spare converting plant is available there is no reason why it should not be erected on well wagons or flat trucks ready for use in emergency.

Grid-Controlled Rectifier in Italy

THE first section of the Italian State Railways to be electrified was the suburban line from Milan out to Varese, which was converted to the 650-volt third rail system in 1901. Subsequently it was extended to Porto Ceresio, and the current is now supplied from the substations at 750 volts. When the line was first electrified throughout there were five substations, each with two 1,000-kW rotary converter sets, but some time ago the use of rectifiers was begun, with the installation, in space which had been reserved for a third rotary set, at Rho substation, about 6½ miles out of Milan station to the north-west. This rectifier is of Brown Boveri's steel-tank type with a continuous output of 1,500 kW at 750 volts d.c., and can be overloaded to 50 per cent. for two hours and to 200 per cent. for 5 min. The transformer is designed for three-phase 42-cycle supply at a tension of 45 kV, and the primary winding has nine tappings per phase to compensate for primary voltage fluctuations between 41 and 45 kV, and for giving a range of d.c. voltages at full load between 600 and 750. Controlled grids for the extinction of back fires are fitted, and the extinction is carried out through a quick-acting relay which causes the grids to be charged negatively when excess currents occur. Provision is also made for the d.c. voltage to be regulated by grid control on the Brown Boveri impulse system. Positive impulses are impressed on different grids, one after the other, and these impulses govern the moment at which the arc ignites on the different anodes. The d.c. voltage can be reduced by retarding the moment of emission of positive impulses with respect to the natural-ignition moments of the anodes, a result attained mechanically by angular displacement of the track of the distributor, or electrically by angular displacement of the magnetic field of the synchronous motor driving the distributor.

A rheostat with hand-wheel drive is used for the voltage regulation, and is inserted in the excitation circuit of the synchronous motor. Regulation is effected by artificial displacement of the field generated by the star-connected excitation winding. The rheostat is built into the switchboard, and can be operated while the instruments are being read. With voltage regulation by means of grid control the tappings on the transformer are used to attain, from the point of view of power factor, the most advantageous voltage ratio to meet the supply voltage and according to what d.c. voltage is required. The grid control apparatus is housed in an insulated steel framework located in a separate cubicle.

New Zealand Electric Locomotives

IN 1936-37 the New Zealand Government Railways decided to acquire ten main-line electric locomotives for operation in the North and South Islands, first for the Wellington—Paekakariki division, the conversion of which to 1,500 volts d.c. was then beginning, and secondly to increase the motive power on the existing electrified section between Otira and Arthur's Pass. Early in 1938 one complete 2-Do-1 locomotive was delivered by the English Electric Co. Ltd., the mechanical portion being built by R. & W. Hawthorn, Leslie & Co. Ltd.; this unit was described in the *Electric Railway Traction Supplement* for February 4, 1938. The electrical equipment for the remaining nine locomotives has been made by English Electric, but the mechanical portions have been manufactured at the Hutt Valley shops of the New Zealand Government Railways. The two locomotives built for the South Island were completed some time ago, and are now being re-erected at the Addington shops, Christchurch, South Island. Four of the seven remaining locomotives are completed and have made their trial runs, and the last three will be finished early in 1940, by which time the track doubling and the electrification over the 25 miles between Wellington and Paekakariki *via* Tawa Flats will be completed. Classified as "ED," these locomotives weigh 88 tons, have a one-hour rating of 1,240 h.p., a maximum tractive effort of 34,000 lb., 45-in. wheels, and a haulage capacity of 250 tons at 55 m.p.h. or 500 tons at 45 m.p.h. A trailing load of 500 tons must be started and accelerated to 20 m.p.h. up a 1 in 57 grade.

With each copy of this issue is presented an index for the Electric Railway Traction Supplements from January 6 to December 8, 1939.

XUM

SINGLE-PHASE LOCOMOTIVE FOR MOUNTAIN LINE

A one-hour rating of 6,000 h.p. at 35 m.p.h., equivalent to 1,000 h.p. per axle, is provided on a weight of 140 tons in the latest standard-gauge locomotives for the Lötschberg route

IN each of the years 1926 and 1931 the Berne-Lötschberg-Simplon Railway put into traffic two 1-Co + Co-1 main-line locomotives with a one-hour rating of 4,500 h.p., for operating heavy passenger and freight trains between Spiez and Brigue. Each of the 1926 locomotives has now covered over 1,000,000 km., and in view of the general satisfaction given by the class it was decided to perpetuate the design when the acquisition of new motive power came up for consideration in 1937. But by taking advantage of the progress made in the design of electrical equipment and electric locomotive mechanical portions during the last few years, it was found possible to develop a double-armature motor of 1,000 b.h.p. on the one-hour rating, and thus to increase the output compared with the four older locomotives by 33 per cent.

The two 6,000 h.p. units ordered from Sécheron and the Swiss Locomotive Works in 1937 have been delivered during the course of 1939, and one of them was shown at the Swiss National Exhibition at Zurich. The use of these locomotives has allowed some of the rod-drive 1-E-1 electric locomotives built in 1913 to be withdrawn from everyday service, a result which the railway company was particularly anxious to attain in view of the high maintenance and repair costs which the original locomotives have always shown.

As the speed of the principal trains over the Lötschberg route has increased during the past decade, it was felt essential that the maximum speed should be raised, and

Driving wheel diameter	1,350 mm. (53 in.)
Motor gear ratio	1 : 5·312
No. of twin-armature motors ..	6
One-hour rating :	
H.p. at wheel rims	6,000
Tractive effort at wheel rims	28,500 kg. (62,800 lb.)
Corresponding speed	56·5 km.p.h. (35 m.p.h.)
Continuous rating :	
H.p. at wheel rims	5,130
Tractive effort at wheel rims	22,500 kg. (49,600 lb.)
Corresponding speed	61·5 km.p.h. (38·2 m.p.h.)
Max. tractive effort at starting	36,000 kg. (79,300 lb.)
Factor of adhesion	3·16
Weight of mechanical equipment (inc. supplies)	78 *tonnes*
Weight of electrical equipment	64 *tonnes*
Total working order weight ..	142 *tonnes*
Adhesion weight in full working order	114 *tonnes*
Top speed	90 km.p.h. (56 m.p.h.)

90 km.p.h. (56 m.p.h.) is permitted for the new locomotives compared with the 75 km.p.h. (46½ m.p.h.) of the older models. The speed corresponding to the one-hour rating has also been increased, and is now 56·5 km.p.h. (35 m.p.h.). In working order the weight is 142 *tonnes* (140 tons), equivalent to 52 lb. per h.p. at the wheel rims on the one-hour rating, which is one of the most favourable values ever attained with a single unit locomotive operating on 15-kV 16⅔-cycle single-phase current.

The new locomotives, Nos. 205 and 206 in the B-L-S list, extend over a length of 20·26 m. (66½ ft.) and have a wheelbase of 16·6 m. (54½ ft.), of which only 4·1 m. (13½ ft.) is rigid. The other leading particulars are as given in the accompanying table

Mechanical Equipment

The mechanical portion of the locomotive comprises a single cab structure carried on two bogies, each of which has three driving axles and at the outer end a Bissel truck. The two bogies, of riveted construction, are connected by an articulation bar located diagonally and a spring coupling, which arrangement, it is claimed, gives easier riding round the numerous sharp curves. The driving wheel bearing springs are equalised down each side of a bogie, but the suspension of the Bissel trucks is separate. The long cab structure is of steel built up in the form of a double-channel girder with the flanges vertical, and allowing of a passage way down each side of a central equipment room. This body is supported through pivots on the bogies, spaced about 9·2 m. (30 ft. 3 in.) apart, but roller supports are mounted between body and bogies near the inner headstocks. The end portions of the body, which carry little equipment, are cantilevered out from the pivots, but here again roller supports are provided below the inner panel of the driver's cab. One of the main pivots is fixed and the other has the usual slight amount of longitudinal play. The arrangement and positioning of these pivots and roller supports ensures even distribution of weight over the driving axles, and eliminates weight transfer due to the drawbar reaction. Side control springs and links bearing upon the cab structure are fitted on the bogies opposite the pivots. The cab structure has blunted, not streamlined, ends compared with the square ends of the 1926 and 1931 locomotives, and seats are provided for the driver and assistant driver.

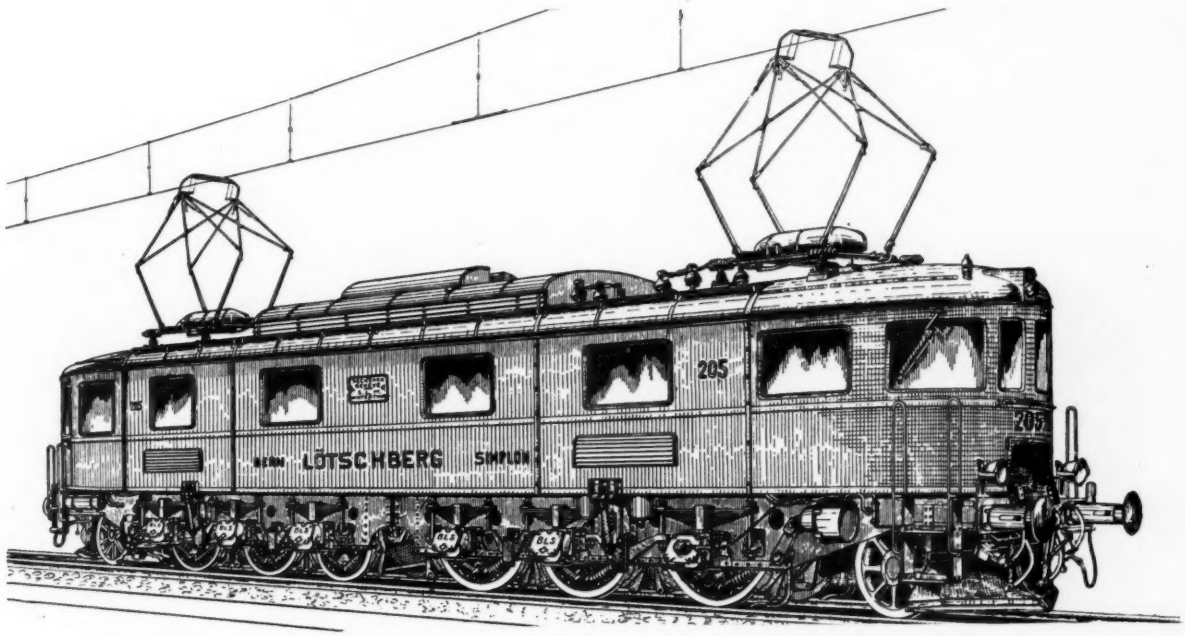
All the driving wheels, but not the truck wheels, are braked by clasp rigging and two tread blocks with renewable shoes per wheel. In addition to a hand brake in each driving position actuating the blocks on the wheels of the adjacent bogie, there is a Westinghouse brake with Weibel-Kradolfer driver's brake valves, and one brake cylinder per bogie. The pneumatic sanding to the wheel treads can be applied to assist either acceleration or braking. An electric rheostatic braking system is incorporated and has 13 braking notches. Standard buffing and draw gear is fitted, and a hinged fall plate can be lowered over the draw gear to give access to the locomotive from the train. Snow scoops are other items of standard equipment.

Electrical Equipment

The general arrangement of the electrical equipment is substantially the same as on the previous locomotives. The pantograph has been improved by the provision of a copper-fitted bow of large contact surface. A special device keeps the rubbing surface of the bow parallel to the contact wire and ensures good collection of current, even at the highest speeds. By fitting the new collector bows to the old locomotives the troubles formerly experienced in the Lötschberg tunnel, due to the enormous accumulation of air in front of the locomotive and the formation of eddies on its roof, have been eliminated. Up to 30,000 km. (18,640 miles) service can be obtained before replacing the copper fittings. In other respects, the pantograph remains unaltered, and is characterised by great lateral stability and small weight. The pneumatic control cylinder and the two draw springs are protected against rain, snow and hoar frost by a sheet-metal cover. The rest of the gear on the roof is the same as on the previous locomotives. Two isolating switches, operated from inside the locomotive

and connected between the pantographs and the main circuit-breaker, permit one or other of the current collectors to be isolated at will. The circuit-breaker, of a type which has been in satisfactory service for years, is fitted with electropneumatic remote control and manually-operated trip gear which can be actuated from the two cabs.

The high-voltage transformer has been modified slightly in accordance with the latest improvements in insulating materials, but the general arrangement remains unaltered, having given complete satisfaction. The transformer is of the auto-transformer type with 12 low-voltage tappings for supply to the traction motors and auxiliary services. The oil is cooled by air flowing through steel tubes expanded into the cover and dipping into the upper layer of the oil, an arrangement which eliminates the circulation of hot oil under pressure and the troubles that may then arise with joints, besides maintaining a more nearly uniform distribution of heat, particularly in the windings. The transformer is of the core type with pancake windings distributed on both cores and wedged axially and radially.



1-Co + Co-1 locomotive with top speed of 56 m.p.h. for the haulage of international passenger and freight trains over the Berne to Brigue section of the Berner-Alpenbahn Gesellschaft

Traction Motors

The traction motors are compensated series-wound machines with shunt-regulated auxiliary poles. Built in pairs permanently connected in series, the twin motors drive through helical-toothed pinions a hollow shaft which in turn drives the wheels through Sécheron individual axle drive. The motor frames, formerly of cast steel, are now built of steel sheet, cut by flame-torch and assembled by arc-welding. There is thus effected an important saving of weight, each component being of the dimensions required by its service, independent of all other considerations. By improvements in ventilation and in the construction of commutators and windings, the one-hour rating of a twin-motor unit has been increased to 1,000 h.p.

As in the previous machines, the rheostatic braking is capable of braking the whole weight of the locomotive. Thirteen braking notches are provided, the motors being excited by line current under the control of the same contactors as used for running. Current produced by the motors operating as generators is absorbed by cast-iron resistances mounted above the second bogie in a flue which communicates with a fresh-air conduit and contains also the shunt-resistances of the auxiliary poles. When the reversing switches are put in the braking position, a grating is opened to allow cool air to pass from the duct into the flue containing the resistances. In order to pass from one of the running notches to braking, the contactor controller is brought to the neutral position, the reversing switch is placed in braking position, and the movement of the controller is then continued until the excitation of the motors is sufficient to produce the desired braking. By means of a relay, the operating handle of the reversing switch is interlocked with the non-recording speedometer so that the reversing switch cannot be changed-over in either direction if the speed of the locomotive is higher than 5 km.p.h. (3·1 m.p.h.), but this does not affect the operations when applying the electric brake.

Control Gear

One of the most interesting innovations in the first 1-Co + Co-1 locomotives placed in service by the Lötschberg company was the use of mecano-pneumatic control of the traction motors. Twenty-four starting and running notches provide the very fine gradation of motor voltage required in locomotives of such high maximum tractive effort, but the interlocking of the contactors would be prohibitively complex with electro-pneumatic control. The Ateliers de Sécheron therefore developed a combined mechanical and pneumatic system of contactor operation, which has since been used extensively with such satisfactory results that there was no hesitation in applying it to the new locomotives. The method combines the advantages of manual operation, in point of clear arrangement,

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easy control and freedom from interlocking contacts, with the merits of electro-pneumatic control as regards high mechanical pressure between contacts, rapid closing and opening independent of the speed at which the driver moves the controller, small effort required from the driver, small travel between consecutive steps of control, and little wear on contacts.

The bank of contactors comprises 24 elements, each consisting of a contactor with its compressed-air cylinder and pneumatic valve, and a camshaft for the opening and closing of the valves. The closing and opening of the contacts is by a rolling action, and the chimneys for the magnetic blow-out are movable to facilitate examination of the contacts. The mechanical interlocking is very simple and consists in preventing the rotation of the camshaft until the contactor to be tripped reaches the open position. The ratio of the gears, transmitting movement from the driver's control wheel to the camshaft, is such that passage from one step of the control to the next corresponds to a quarter-turn of the handwheel. Very little torque is required to operate the latter, and to avoid any possibility of damage by the driver forcing the handwheel while the camshaft is locked, a friction clutch is provided. If excessive force be applied this clutch slips, and by its slipping actuates the trip of the main circuit breaker.

It is sometimes necessary to disconnect all the motors instantly. This can be done, where electro-pneumatic control is employed, by bringing the controller drum quickly to the off position. At first sight, the matter is less simple where mecano-pneumatic control is used, but actually instantaneous interruption of the motor current is effected at any position of the controller by pressing a button on the driver's panel. This has the effect of slightly displacing the camshaft axially, thus releasing all the contactors which are in the closed position. Normally, the camshaft is held in position by the piston of a compressed-air cylinder against the action of a spring. Pressing the release button opens an electro-magnetic valve and allows air to escape from the camshaft cylinder, whereupon the spring displaces the camshaft and instantly releases all the contactors. The driver then returns his handwheel to off, thus reclosing the electro-magnetic valve; air pressure is then re-established in the camshaft cylinder and the camshaft is moved back to its working position. There are always four contactors closed on the normal running notches, each contactor carrying only one-quarter of the total current.

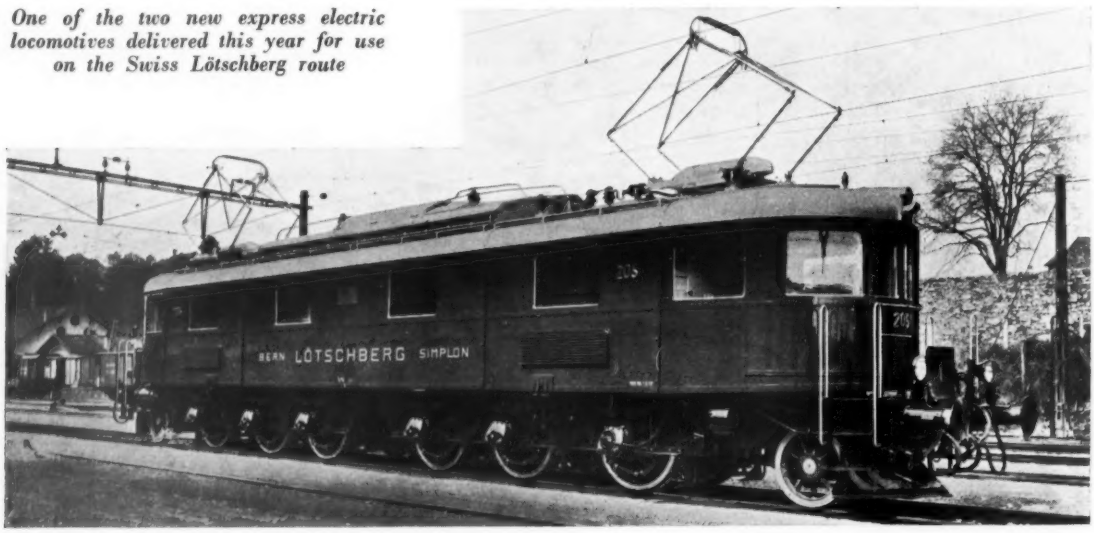
The reversing switches are arranged in two groups of three, one group for each main bogie. Each reversing unit acts on one twin motor and has the four positions: forward, stop, brake, and reverse. A compressed-air servo-motor operates each group of reversing switches. It is a relatively simple matter to take any motor out of circuit and to lock its reversing switch in the off position.

Auxiliary Circuits and Miscellaneous

The auxiliary motors are operated by single-phase, $16\frac{2}{3}$-cycle a.c. at 220 volts. The ventilation system is divided into two equal and symmetrical parts. Above each bogie there is a fan driven by two overhung series motors, one on each side of its casing, an arrangement which makes the motors very accessible and allows the fan speed to be nearly doubled by connecting the two motors in parallel instead of in series. Each fan supplies air to a duct which serves the three traction motors through leather connectors, and also supplies cool air to one of the sets of cooling-tubes in the transformer. The fan on the second bogie also supplies air for cooling the braking resistances. Compressed air, for the Westinghouse brake and the pneumatic operation of various apparatus and the current-collecting gear, is supplied by two rotary compressors, each rated at 1,320 litres (46·6 cu. ft.) per minute. These compressors are controlled manually from the driver's cab or automatically by a pressure-regulator. A single-phase a.c.-d.c. converter set, in parallel with storage cells, supplies d.c. at 36 volts for control circuits. The train-heating circuits are supplied with single-phase a.c. at 800 or 1,000 volts, as the case may be, from two tappings on the main transformer.

The controls have been arranged so that the driver can be seated. All the controls are assembled in the controller unit, in front of which there are mounted the line voltmeter and the ammeters measuring the total primary current and the current in each motor. Air-operated wipers are fitted to the front windows of the cab, which are of non-frosting glass, thus ensuring a clear view of the track even in cold or rainy weather, or while snow is falling. As the locomotives will normally be driven by one man, they are fitted with a dead-man safety device and with the Swiss standard Signum automatic train control apparatus.

One of the two new express electric locomotives delivered this year for use on the Swiss Lötschberg route



HIGH-TENSION 50-CYCLE LOCOMOTIVE

Shop trials of the U.S.S.R. experimental unit have now been finished

AT the end of last year the Dynamo Works at Moscow completed the construction of an experimental locomotive for the 50-cycle 20-kV single-phase system. Like the German Höllentalbahn locomotives, it comprises single-phase/d.c. apparatus and incorporates a mercury-arc rectifier with grid control. The general mechanical details of the traction motors are to Soviet accepted standards for d.c. electric locomotives, but owing to the heavier equipment such as the transformer and rectifier, the cab structure has been fabricated on special lines. The locomotive is of the Co-Co type and weighs 132 metric tons; the weight is distributed fairly evenly over all the axles. The wheel diameter is 48 in. and the output on the one-hr. rating is 2,040 kW at 37 km.p.h. (23 m.p.h.), at which speed the tractive effort at the wheel rims is 20,000 kg. (44,000 lb.).

Main Circuits

The main equipment comprises two pantographs, a single-phase oil switch with electro-pneumatic gear, transformer unit consisting of one main and one auxiliary transformer enclosed in the same tank, a 12-anode rectifier with smoothing equipment, and six nose-suspended d.c. traction motors. The traction motors are force-ventilated by two motor-blower groups, and the auxiliary equipment further includes two motor-driven compressors and a fan-cooled radiator in the water-circulating system in the rectifier.

The main power circuit of the locomotive and a simplified diagram of the rectifier regulation and protection is shown in Fig. 1. Single-phase current at industrial frequency is taken from the contact line by two pantographs 1 and is supplied to the primary winding of the main transformer 3 through oil switch 2. From the secondary winding of the main transformer the current is led to the rectifier 6. Starting and speed setting are effected by regulating the value of the d.c. voltage by grid control at the rectifier anodes. The 12 anodes are arranged in two phase-groups with five anodes in each, and there is a further group of neutral anodes consisting of two separate anodes. Equal distribution of the load between the two groups working in parallel is carried out by the three anode reactors, 5. Two of these reactors have five windings for the phase anodes, and one has two windings for the neutral anodes.

Rectifier Pulsations and Voltage

Smoothing of the rectifier pulsations is carried out by the smoothing choke coil 13 in series with the group of traction motors, and also by shunting the traction motor field windings by the ohmic resistances 8. The a.c. component of the rectified current flows through these ohmic resistances, leaving a steady excitation current in the field windings of the traction motors.

Should any defect occur in working, the traction motors can be disconnected individually, and in such cases the decrease in power is not in proportion to the number of the disconnected motors. It is somewhat less on account of the increased pulsations due to the smaller pressure drop in the smoothing choke coil. Motor reversal is carried out by changing over the field windings.

Regulation of the value of the rectified voltage, permitting smooth operation of the locomotive at any desired speed, is performed by rotating the phase regulator 21, situated on the driver's controller. On the blocking voltage uninterruptedly supplied to the grid of the phase anodes in the rectifier from generator 15, there is superimposed an alternating component derived from the phase regulator and converted to the form of two peaks per cycle by the highly saturated transformer 22. The positive peaks overcome the negative bias voltage of the grids and fire the corresponding phase anodes.

Grid Control

By turning the phase regulator, the phase of the grid voltages is changed with regard to the voltage on the phase anodes so that, for example, the positive peak or firing impulse, which is given at the end of the positive half-cycle of anode voltage when the controller is in its neutral position, is shifted to the beginning of the half-cycle by turning the phase regulator to 180 deg. The duration of burning of the group of anodes is increased as firing is made to occur earlier. The voltage supplied to the traction motors, equal to the mean value of the rectified voltage for the half-cycle, can thus be varied from zero to a maximum.

Owing to the power factor of the installation being low at low values of the rectified voltage, and in order to obtain greater economy on the middle range of speeds, it was necessary to adopt a scheme allowing half the voltage from the intermediate terminals of the secondary winding of the main transformer to be applied to the mercury rectifier.

Thus, on the first step of the connection (from the intermediate terminals of the transformer) the voltage applied to the traction motors can be varied between 0 and 750. On changing to the second step, the rectifier is fed from the end terminals of the main transformer and the firing impulses are applied to the grids at the middle of the half-cycles of anode voltage (90 deg. position of regulator). The tension applied to the traction motors thus remains at 750 volts after the change-over, but by further rotation of the phase regulator the voltage can now be increased to 1,500.

Protection against short circuits in the power circuit of the locomotive is provided by a special instantaneous relay the operating coil of which opposes the flux of the hold-on coil. The opening of the relay contacts interrupts the circuit from the phase regulator and stops the supply of positive-peak firing impulses to the phase anodes of the rectifier, thus leaving the anodes blocked by the negative grid bias. The traction motors are protected against overload by relays connected in the circuit of each motor. Operation of these relays breaks the circuit of the hold-on coil of the instantaneous relay and results in blocking the rectifier as explained above.

Grid Protection

The rectifier itself is protected against back firing by the grid instantaneous relays, one of which is connected to a current transformer in the primary circuit of the main transformer. The deionising action of the grids increases after the opening of a secondary instantaneous relay, the contacts of which short circuit the primary winding of the peak transformer and thus interrupt the

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supply of firing impulses to the grids of the phase anodes. After an interval, compared with the instant action of grid protection, the oil switch is opened, its trip coil being excited from the contacts of the intermediate relay connected in series with the bottom of the secondary instantaneous grid relay.

In the event of a short circuit to earth on the primary winding of the main transformer, or in the auxiliary transformer, the oil switch is opened by the action of an overload relay fed from a current transformer in the high voltage lead from the pantgraphs. Fig. 2 gives the main scheme of the auxiliary connections of the locomotive.

Auxiliaries

The auxiliary machines of the locomotive, viz.: compressors, fans, pumps and the like, are driven by squirrel-cage three-phase induction motors, each with a remote-controlled electromagnetic contactor. Three-phase supply for these motors is provided by a phase-splitter consisting of a synchronous machine with two stator windings electrically in quadrature. One of these windings, called the motor winding, is supplied at 220 volts from the auxiliary transformer and produces an alternating magnetic flux, the inverse component of which is neutralised by the cage of the rotating rotor. The other stator winding, the generator winding, is connected at one end to the mid-terminal of the motor winding, and the rotating field induces in it an e.m.f. in quadrature with that in the motor winding. The rotor slots of the phase splitter contain, besides the squirrel cage, an exciting winding fed with direct current at 50 volts. This establishes the main magnetic flux in the machine and relieves the " motor winding " on the stator from magnetising duty. The use of an appropriate number of turns in the generator and motor windings on the stator permits a symmetrical three-phase supply to be taken from the end terminals of the motor winding and the free terminals of the generator winding, for the fans and pumps under normal load.

Regarded as a motor, the phase splitter is a single-phase machine with no inherent starting torque, but by connecting a choking coil in series with the " motor winding " and a resistance in series with the " generator winding," a starting torque is obtained. To shorten the time required for starting, the control generator direct-coupled to the phase splitter is operated temporarily as a shunt-wound motor taking current from the storage battery of the locomotive. The various starting operations and the establishment of normal working connections are all effected automatically under push-button control.

Besides the auxiliary machines, the auxiliary transformer

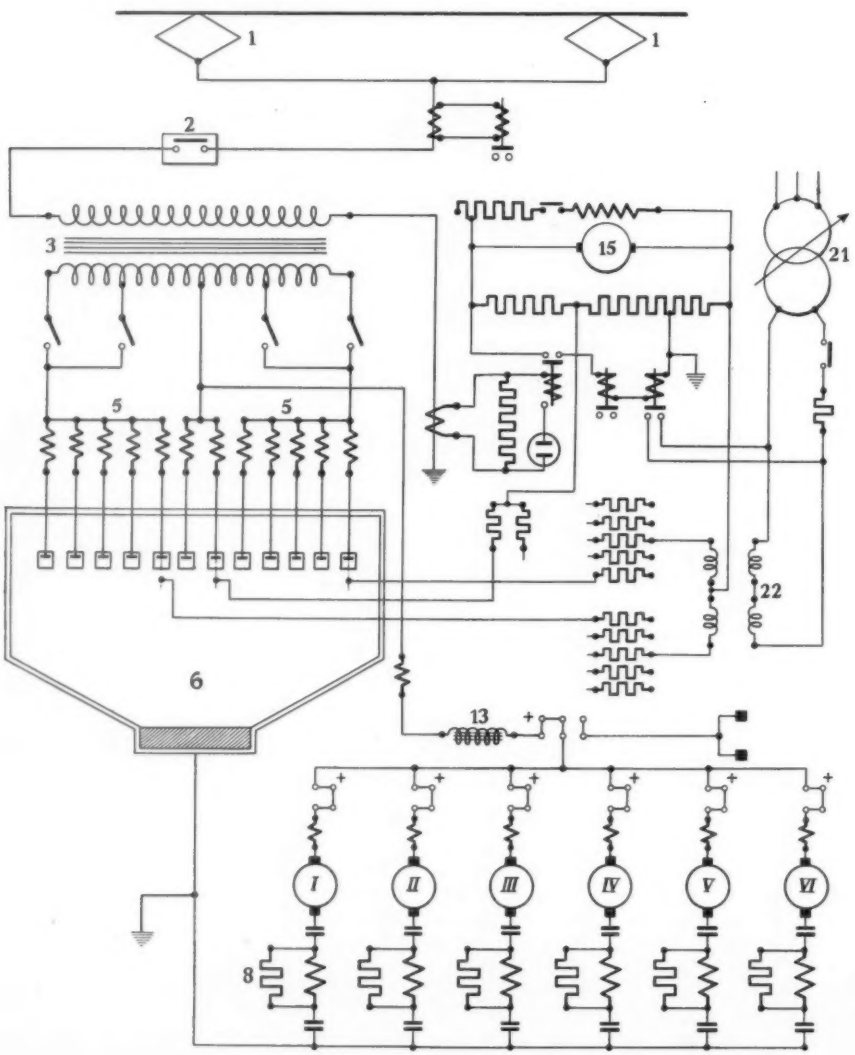

Fig. 1—Main power circuits of U.S.S.R. experimental 20,000-volt 50-cycle single-phase electric locomotive

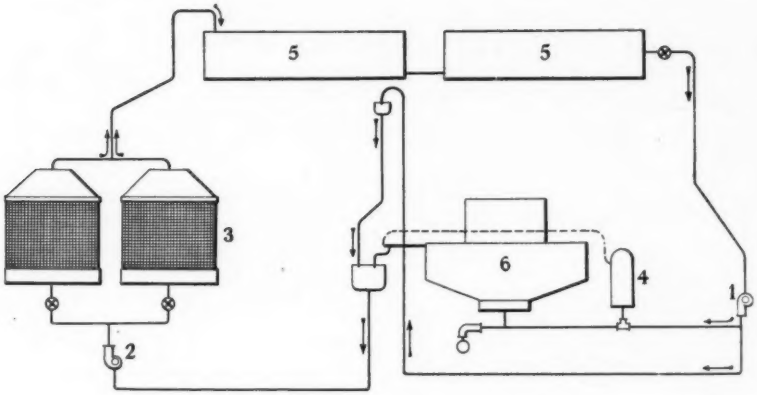

Fig. 2—Diagrammatic representation of auxiliary circuits of the high-tension industrial-frequency single-phase locomotive, the electrical equipment for which has been completed in Moscow

serves the primary winding of the ignition transformer and the mercury pump which is automatically changed over to the accumulator when the oil switch is opened. All the instruments necessary to current and voltage control in the high-voltage and traction motor circuits are mounted in the driver's cab, together with an electric vacuum gauge which measures the vapour pressure in the rectifier steel tank.

Rectifier Cooling

A closed air-cooled circulating water system is used for cooling the rectifier. As shown diagrammatically by Fig. 2, water heated in the jacket of the rectifier 6 is delivered by centrifugal pumps 1, 2 to a group of radiators 3, whence it returns to the rectifier. The radiators are fan-cooled, and a thermostatic valve 4, regulated by the temperature of water at the jacket outlet, controls the rate of circulation as required to maintain the correct temperature in the rectifier.

When the locomotive is coasting or running on light load, the thermostatic valve 4 may be nearly or quite closed, but water is still circulated *via* the by-pass pipe and therefore continues to be cooled. This arrangement, together with the provision of tanks 5 to increase the amount of water in the circulating system and thus its heat capacity, permits the losses of the rectifier to be dissipated with only a small increase in temperature of the water above normal when the locomotive is working heavy loads on gradients. The mercury pumps of the rectifier are cooled by a special water-cooling system with a compressor-type refrigerator of 700 cal. hr. (2,780 B.Th.U. per hr.) capacity.

Notes and News

Brünig Rolling Stock.—Orders for the complete electrical equipment for the motor-coaches for the Brünig metre-gauge line have now been placed, and are divided between Brown Boveri, Oerlikon, and Sécheron.

Spanish Conversion.—The Spanish Government has decided that the railway authorities shall push on with the Madrid-Avila and Segovia lines of the Norte, conversion of which began before the civil war. It is hoped that electrification will be extended to other lines.

Brazilian Electrification.—The Brazilian Government has authorised the Ministry of Communications to proceed with the electrification of the 87-mile São Paulo-São Antonio section of the Sorocabana Railway. According to present plans the conversion of the double-track São Paulo-Sorocabana section to 3,000-volt d.c. must be terminated within two years of the signing of the agreement, and the remainder of the line within another 12 months.

Belgian Corrections.—The second route between Brussels (Nord) and Antwerp has not been electrified as we stated in our issue of October 13. What actually took place was that new stations were built on the existing electrified lines so that all-stations stopping trains could be run with electric traction, as well as the fast and semi-fast services operated since the conversion in 1935. Hitherto stopping trains have been worked by steam or by railcars along the tracks used by the international and goods steam trains. A stopping electric train is now run in each direction once an hour, and every half hour at peak periods, and are sandwiched between semi-fast trains. In connection with the Midi-Nord connecting line now under construction, the existing Brussels-Antwerp electrified line has been diverted slightly between Brussels (Nord) and Schaerbeek, and the electric trains now use platforms 9, 10 and 11 in the centre of the Nord station, instead of the easternmost three as previously.

LETTER TO THE EDITOR

Traction Motor Gears

Birmingham,
November 24, 1939

TO THE EDITOR OF THE ELECTRIC TRACTION SUPPLEMENT

SIR,—In connection with the article on Traction Motor Gears published with your issue of November 10, the following are some comments.

If twin gears are used it is essential that they be sprung or have a small helix angle with suitable end play. Otherwise it is impossible to get reasonably even distribution between the two gears. Armature speeds up to 9,000 ft. per min. are now used, as against 7,500 ft. given as the maximum in the article. The life of a gear depends to a large degree on the maximum speeds, because the question of lubrication at speed is of great importance. The permissible tooth speed is fixed mainly by (*a*) accuracy of profile; (*b*) ability to maintain lubrication; (*c*) finish of surface; and (*d*) considerations of permissible gear wear. Is there anything in actual experience to suggest that the Maag tooth should permit a higher speed than a standard 20° involute. As regards pinions, it should be noted that the shrink fit carries the load, and the key is therefore simply an additional security. The larger gear wheels are seldom fitted with keys. TRACTION DESIGNER

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OVERHEAD CONTACT LINE OR THIRD RAIL?

A meteorological consideration of the problem

By DONALD L. CHAMPION, F.R.Met.S.

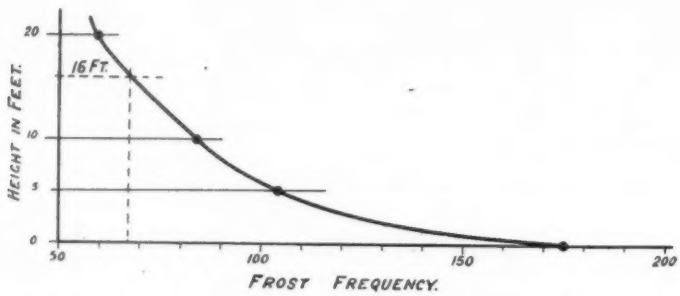


Fig. 1. Chart of frost frequency at various heights above ground level

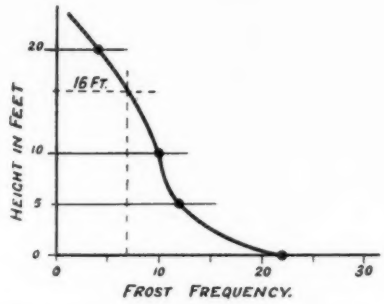


Fig. 2. Number of frosts experienced during the month of April

RECENT delays on electrified systems, due to the deposit of ice on live rails, seem to indicate that even in the London suburban area the occurrence of sharp frosts can cause considerable difficulty in the running of trains which take up their power from live rails.

At Goff's Oak meteorological station, Hertfordshire, during the past three years considerable data have been obtained from radiation thermometers exposed at ground level and at heights of 5, 10, and 20 ft. from the soil for the purpose of an investigation into the frequency and intensity of radiation frosts. The instruments used were standard Meteorological Office pattern minimum thermometers, freely exposed to radiation so that the intensity of the latter might be estimated by subtracting the minima obtained from the minimum air temperature as ascertained from the standard thermometer in the thermometer screen.* Altogether, data for 424 nights are available, and in Fig. 1 is given a curve showing the frequency of frost (minimum 32° F. or lower) at all levels between the surface and 20 ft. It will be seen that 175 frosts were recorded on the ground against only 59 at 20 ft.

Since the deposit of hoar and rime on conductors frequently leads to the complete insulation of the collecting shoes or pantographs, it follows that by interpolation, a conductor wire at 16 ft. might have experienced frosting on a possible 67 nights against 175 in the case of a conductor rail. Intensity of frost, however, also varies considerably with height, due to the inversions of temperature gradient usually associated with the calmer air and clear skies of spells of frost in the London area.

Taking the month of April, 1938, as a typical example, it will be seen from Fig. 2 that 22 frosts were recorded at the surface and only 4 at 20 ft., so that, by interpolation, 7 frosts occurred at 16 ft. Fig. 3 shows the mean deviation of radiation minima from air temperature minima, and assuming the mean air minimum to have been 32° F., there would have been an average of 8·44° of frost at the surface and only 0·27° of frost at 20 ft. The resultant heavier deposit of ice on conductor rails compared with that on a conductor wire at 16 ft. is obvious.

The curve in Fig. 4 shows the conditions on the night of April 12/13. This curve is particularly interesting since the minimum air temperature was 2° above the freezing point, but even so, the surface temperature was lowered by radiation to 21° F. and hoar was deposited, whereas at 20 ft. the minimum was within 0·1° of the minimum air temperature and no hoar would have formed on objects exposed above 6 ft. from the soil.

It should be noted that this meteorological station is on a hill, at an elevation of 330 ft., and since railways usually follow valleys, the chance of frost on the tracks is higher owing to the katabatic drift of air cooled by radiation on the slopes, rendering the air in the valleys initially cooler.

Since a conductor rail is probably a far better radiator than the natural soil, it follows that there may be a greater frequency of frost experienced on rails than on the ground, and from the data given above, it would seem that there must be a greater frequency of ice deposit on conductor rails than on conductor wires 16 ft. above ground level. When one considers also the occasional heavy snowfalls and comparative rarity of glazed frosts, it would seem that in this country the conductor wire is far less liable to failure from meteorological conditions than is the third rail.

* Air Ministry, Meteorological Magazine, Vol. 71, page 129

Fig. 3. Mean deviation of radiation minima from air temperature minima

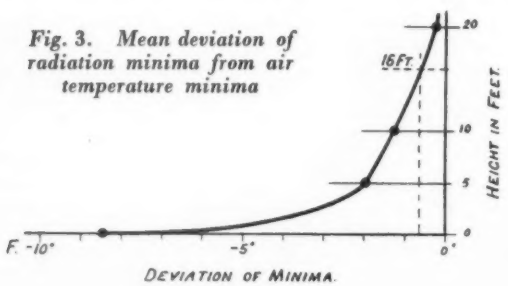
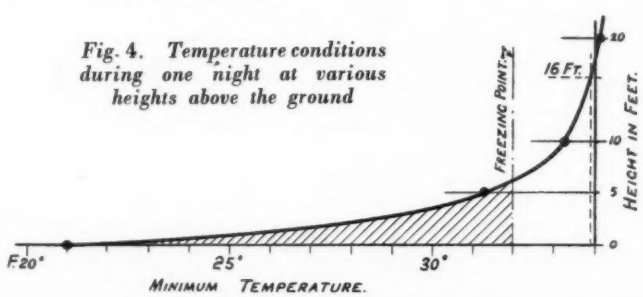


Fig. 4. Temperature conditions during one night at various heights above the ground



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THE YEAR 1939 IN RETROSPECT

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The photograph below is of a Draftgear Member of mild steel, entirely fabricated by Electric ARC Welding. It is for the Chinese National Railways and was manufactured by the Birmingham Railway Carriage and Wagon Company Limited.

Investigate the possibilities of Electric ARC Welding as applied to your construction problems. Murex will be pleased to assist and advise you.

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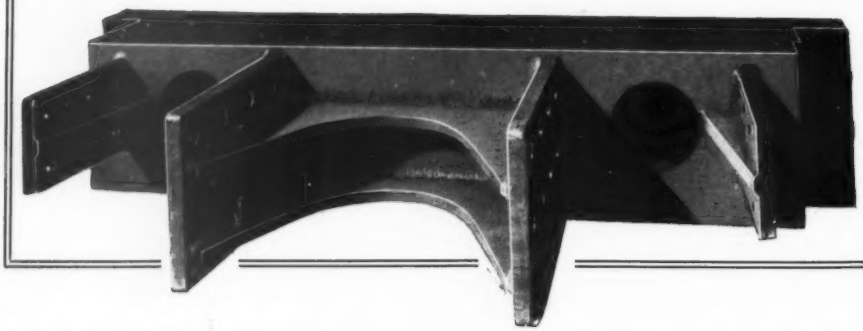

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The Body is made of Hadfield's Best Toughened Cast Steel, and Drawbar Tongue, Locking Catch, Releasing Handle, and Buffer Head Wearing Plates of Hadfield's Patent

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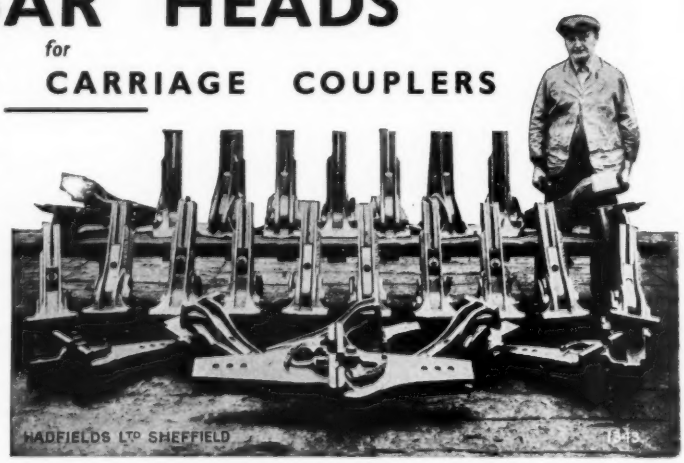
MANGANESE STEEL

The Supreme Material for resisting wear.



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Drilling hole in Nickel Chrome Molybdenum steel Cap with 3¼in. diameter Twist Drill made from Vanadium Premier Steel.

STOCKS of most sizes of regularly used Standard Milling Cutters, Reamers, Drills and Taps are maintained at these Works.

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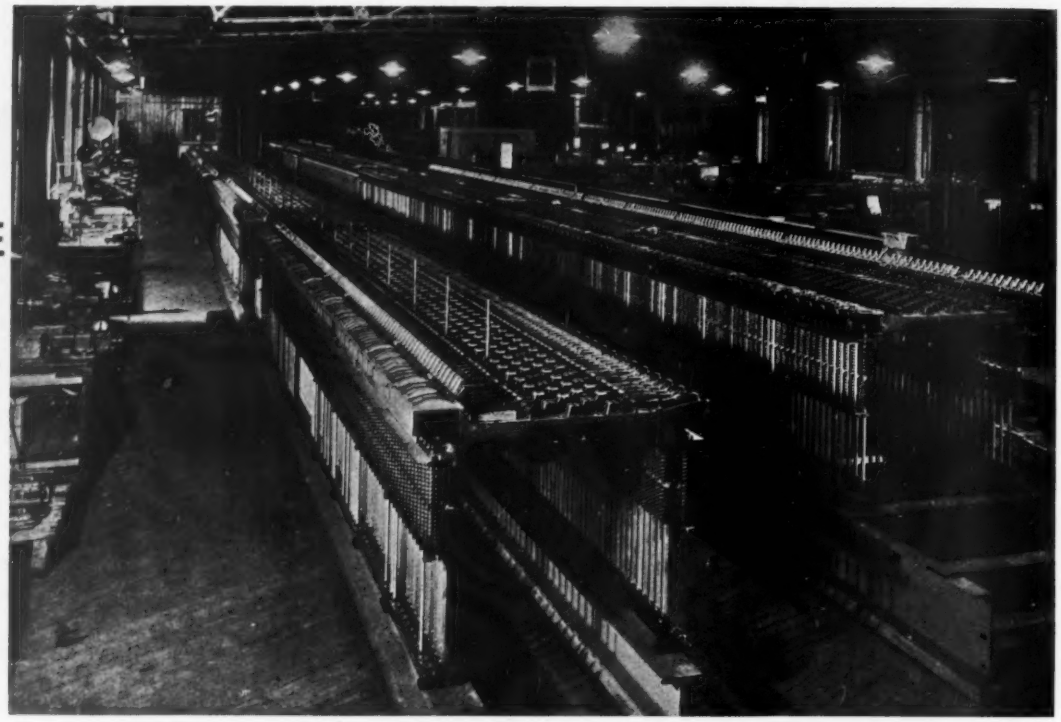
SAY YOU SAW IT IN "THE RAILWAY GAZETTE"

Power f



A very recent photograph taken in the erection shop in the

Westinghouse

Factory at Chippenham, showing a number of power interlocking frames of various types and in various stages of completion, being constructed to orders received from Railway Companies in Britain and other parts of the world.

●

Since this photograph was taken some of the frames shown have been dismantled and despatched ; other frames are being erected in their place.

●

WESTINGHOUSE BRAKE & SIGNAL CO. LTD.

Represented in—AUSTRALIA : Westinghouse Brake (Australasia) Pty., Ltd., Concord West, N.S.W. (for BRAKES)
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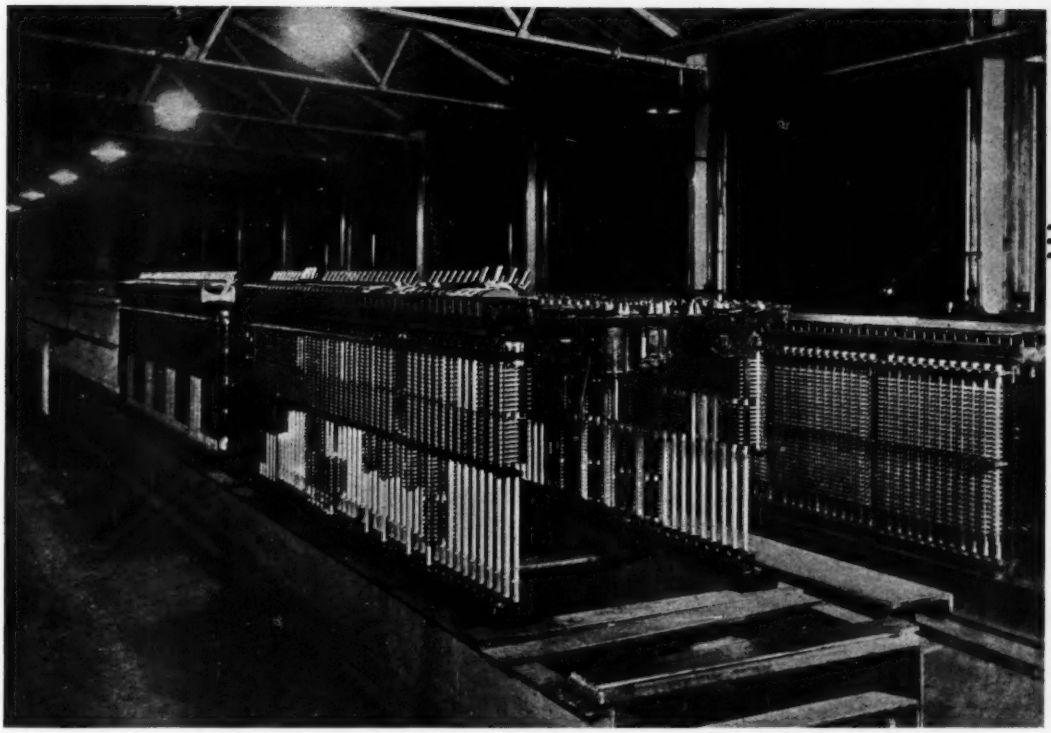
INDIA : Saxby & Farmer (India) Ltd., Calcutta and Bombay.

frames



Since 1897

Westinghouse Brake & Signal Co. Ltd., and its predecessors, have built in their own shops 366 power interlocking frames containing 17,239 levers.

●

As an indication of the manufacturing facilities now available in the factory, during 1938 and 1939, 34 frames will have been put in hand, totalling 1881 levers.

●

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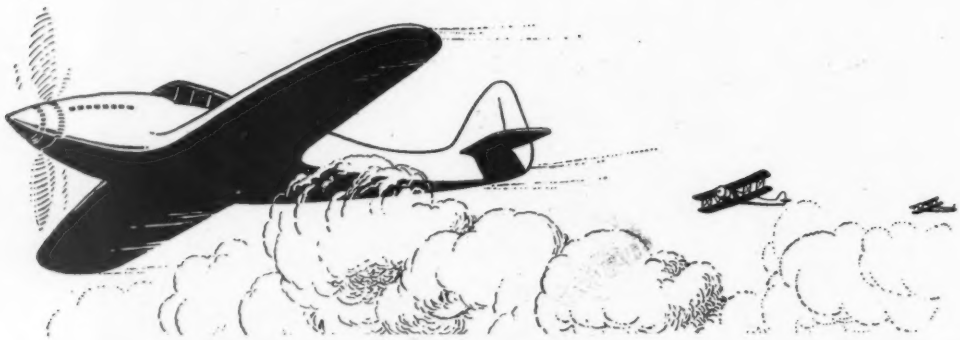
SAY YOU SAW IT IN "THE RAILWAY GAZETTE"

HOLBROOK



FLYERS *To be miles ahead of the other fellows means that you must just have that extra something.*

Shop executives in Britain, Australia, Canada, India, South Africa, and elsewhere are getting that extra something on the MODEL "B" HOLBROOK LATHES.

- ACCURACY OF PITCH
- PATENT LEAD SCREW THRUST
- PATENT BALANCED DRIVE CLUTCH
- PATENT DRIVE IN HEADSTOCK
- FINGER TIP CONTROL TO FEEDS
- DISTANCE TRAVELLING DIAL
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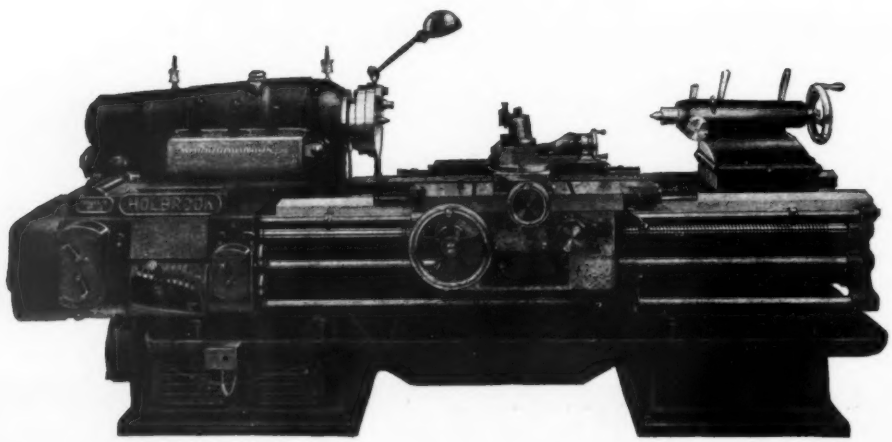
- PRECISION QUICK WITHDRAW

Single Helical Drive by only one gear on main spindle mounted on 4 precision Timken Taper Roller Bearings, all gears hardened and Tooth Profile ground by generating, giving a **SILK-LIKE FINISH ON ALL WORK** . . . .

That is some of the extra something



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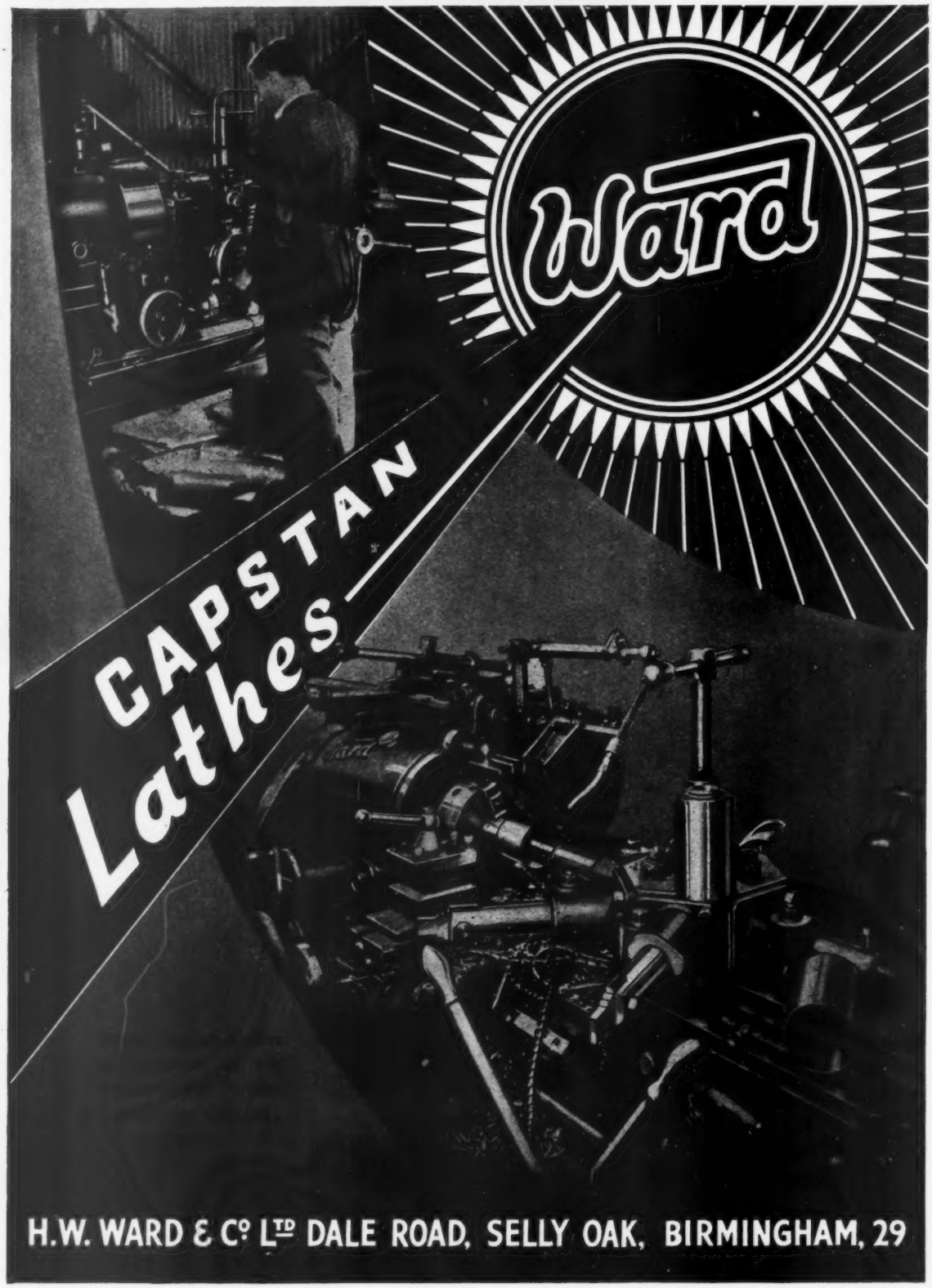

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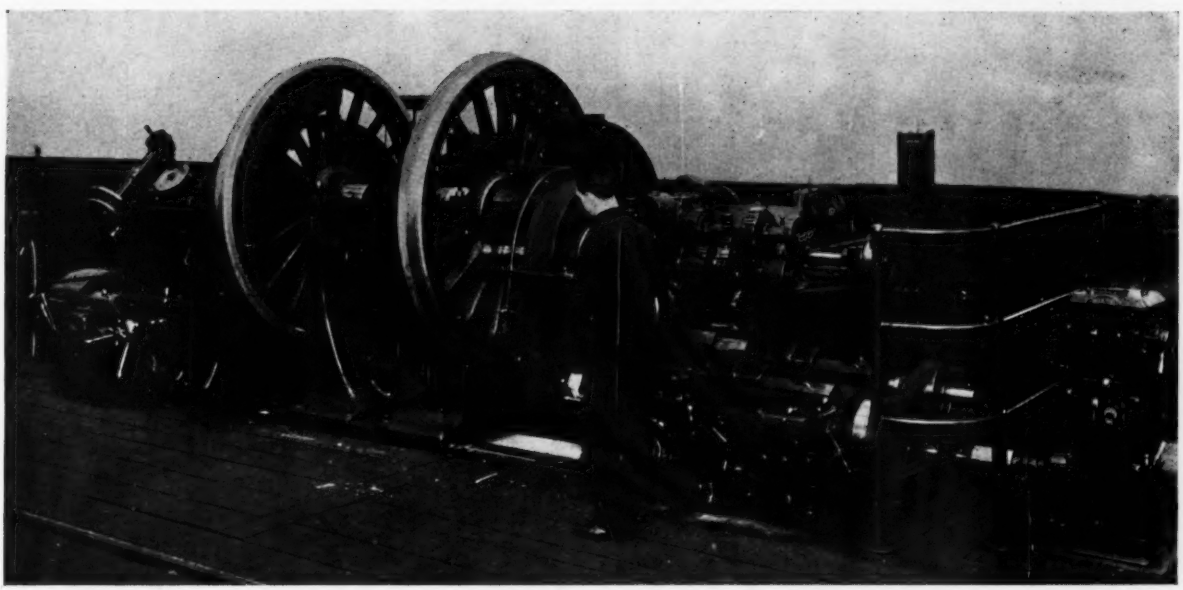
AT L.M. & S. RLY. ST. ROLLOX WORKS
Crank-pin Grinding and Quartering Machine

"The machine is used for work on the crank-pins of outside cylinder engines only, and it has attachments for boring and grinding crank-pin holes. Adapters are provided for dealing with crank-pins set at 120° if required. The machine, we are informed, has been particularly valuable in correcting the quartering of the crank- and coupling-rod pins on the older types of engines, and whilst giving a very greatly improved finish over the earlier and less adaptable type which it replaces, also shows a saving in time of approximately 25 per cent., this being mainly due to the speed at which it can be set up."

(Reprinted from "The Railway Gazette," May 26th, 1939)



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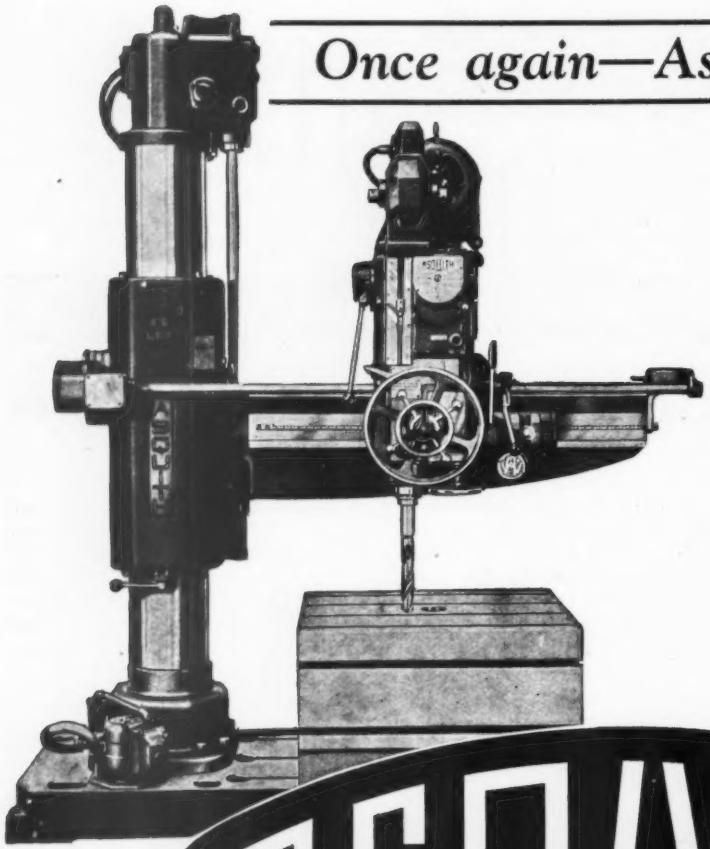

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Capacity: 1½in. from solid in steel and 2in. in cast iron. Tapping up to 1in. Whit. in steel.

Two sizes: 3ft. 6in. and 4ft. 6in. radius. Write for the L.D.R. brochure.

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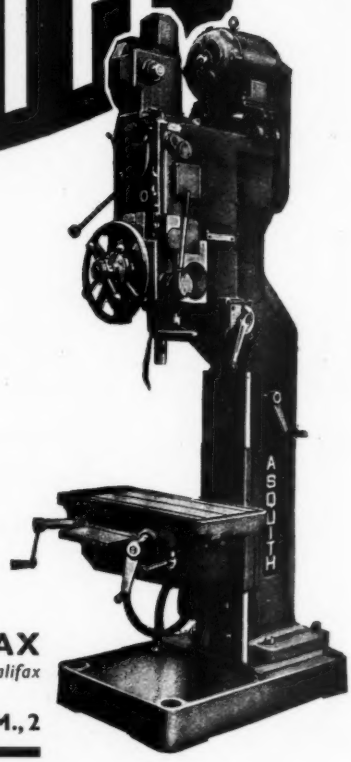

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This model maintains the Asquith traditions for general handiness, reliability and high productive capacity. There are many distinctive features and the machine is worth your immediate investigation. Various forms of worktables are available and the machine will drill up to 1½in. diameter in steel and 2in. in cast iron. Tapping can be performed up to 1in. Whitworth in steel. Brochure R73 on request.

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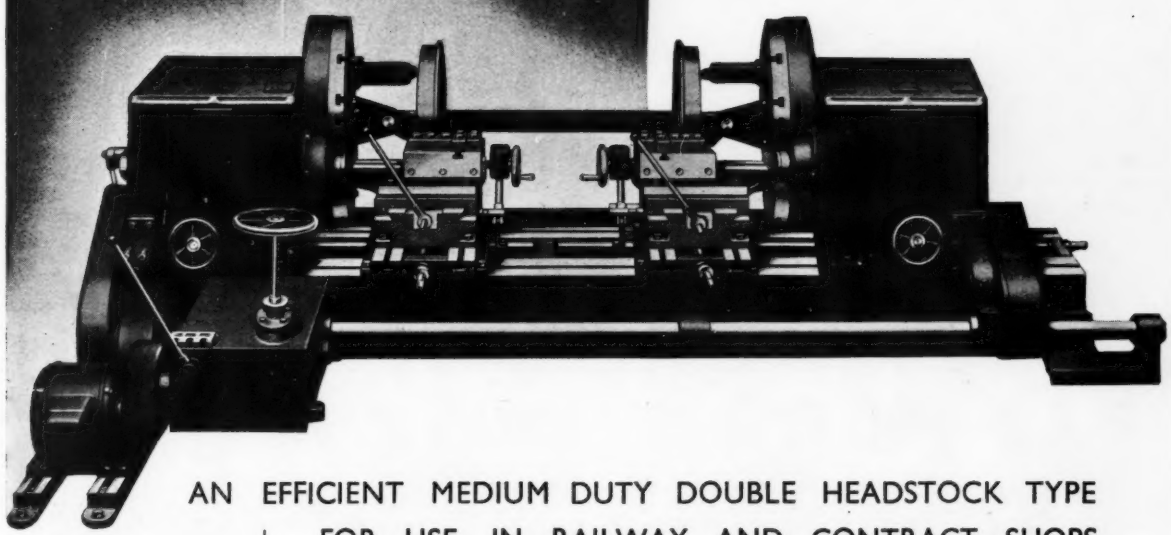

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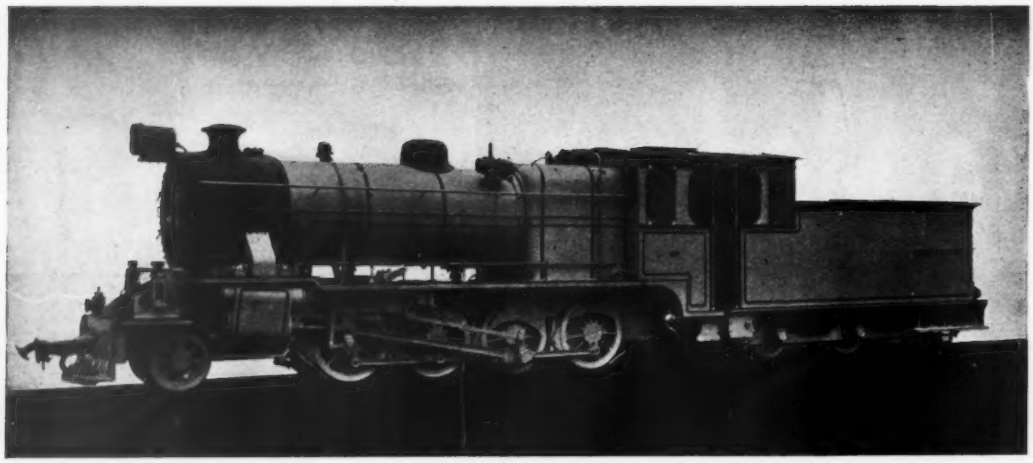

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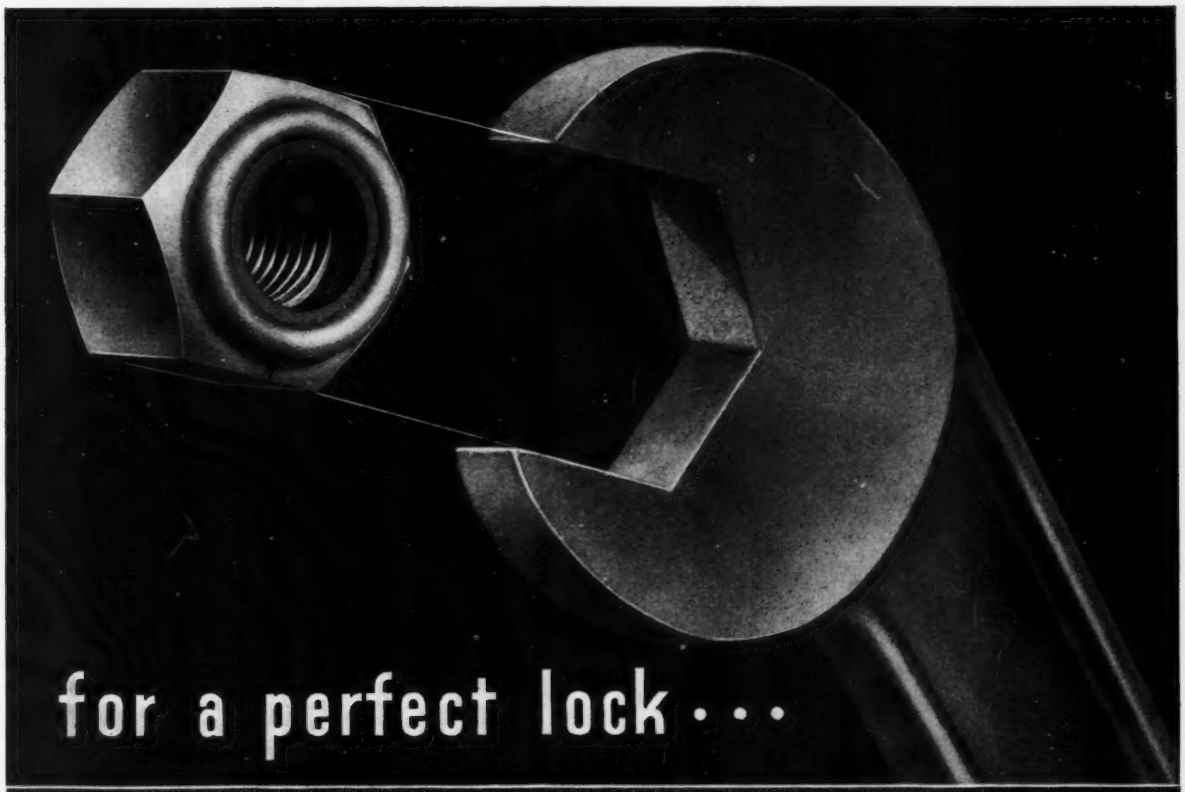

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It is self-locking to the actual threads of the bolt and locks independently of any seating surface. Easy to fit or remove—all that is needed is a spanner.

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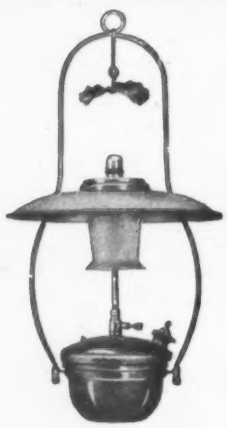

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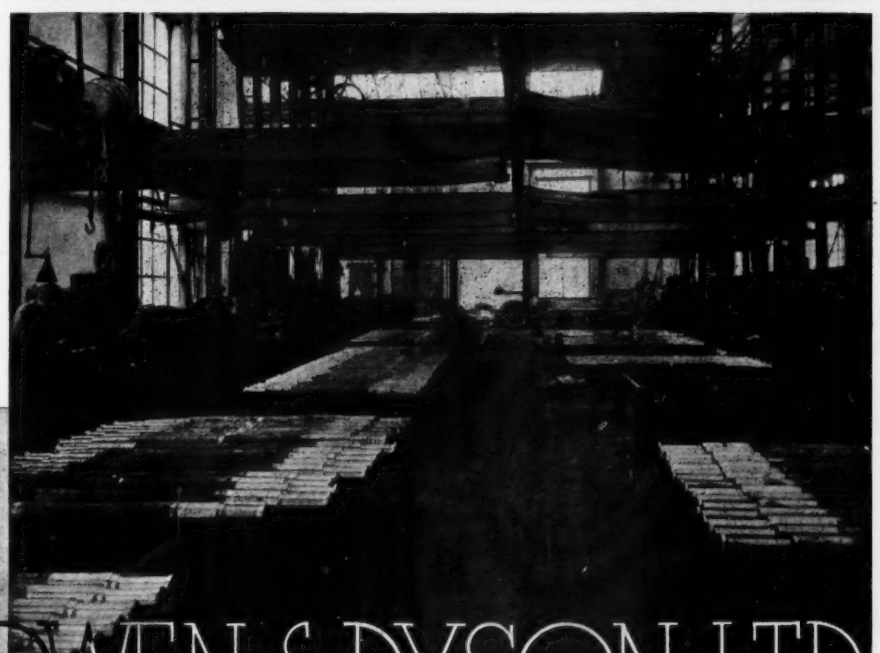

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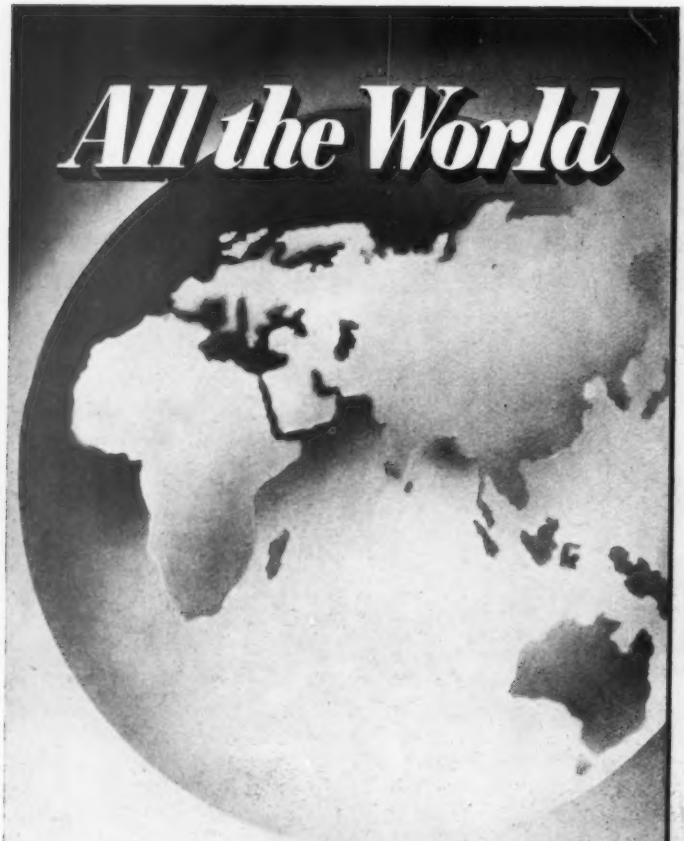

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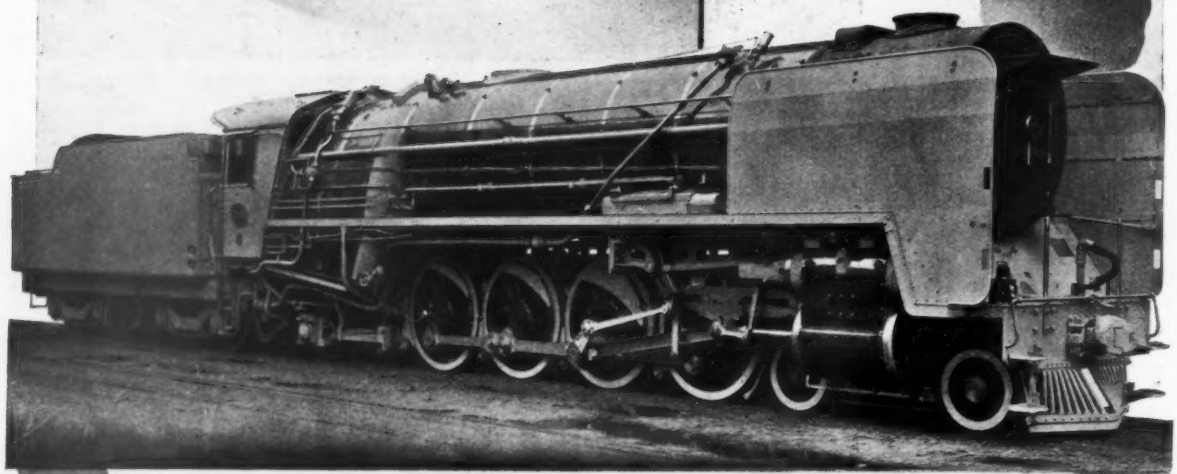

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4-8-2 Type, Class 15 F Locomotive
44 RECENTLY CONSTRUCTED BY THE

NORTH BRITISH LOCOMOTIVE Co LTD
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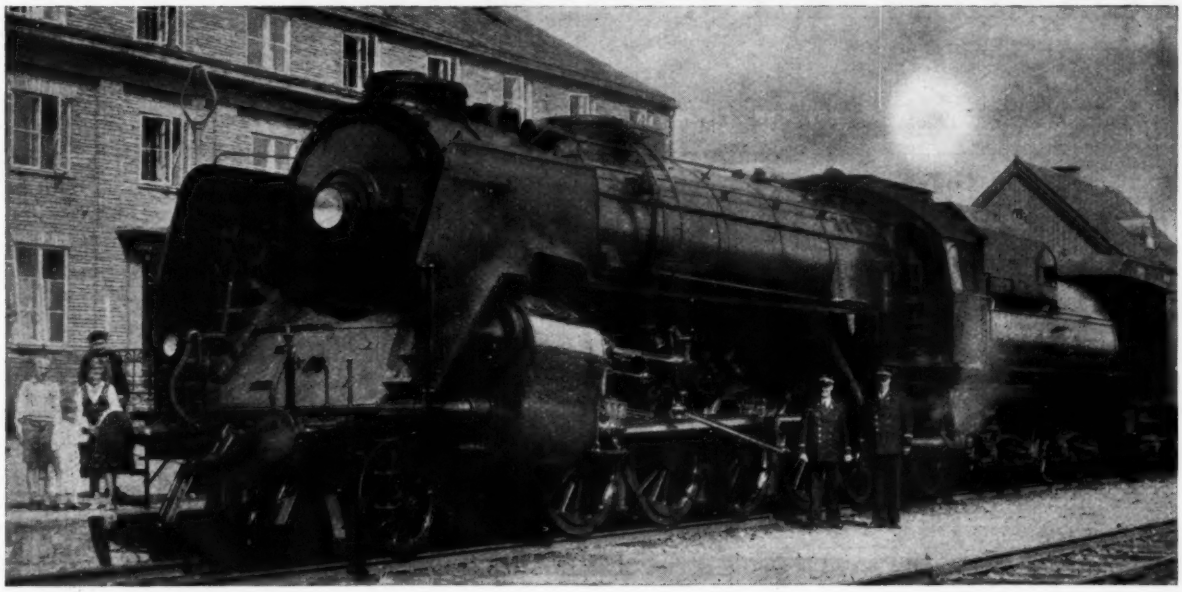
IN THE LAND OF THE MIDNIGHT SUN . . .



Three powerful but lightly constructed four-cylinder 2-8-4 type locomotives built by Thunes Mekaniske Vaerksted, Oslo for the NORWEGIAN STATE RAILWAYS are each equipped with two Nicholson Thermic Syphons.

These locomotives were introduced last May on the Oslo-Bergen section and notable accelerations have resulted. Officials of the state railways are enthusiastic over their performance.

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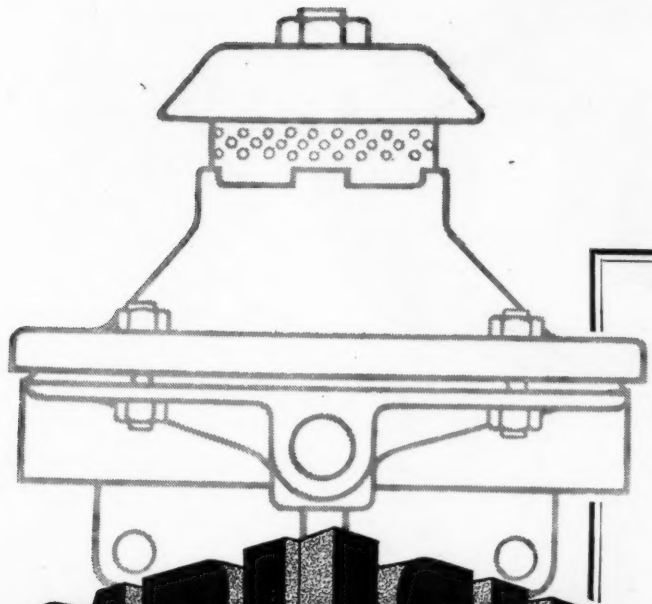

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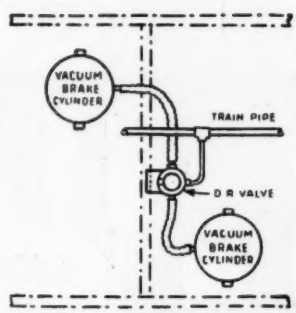

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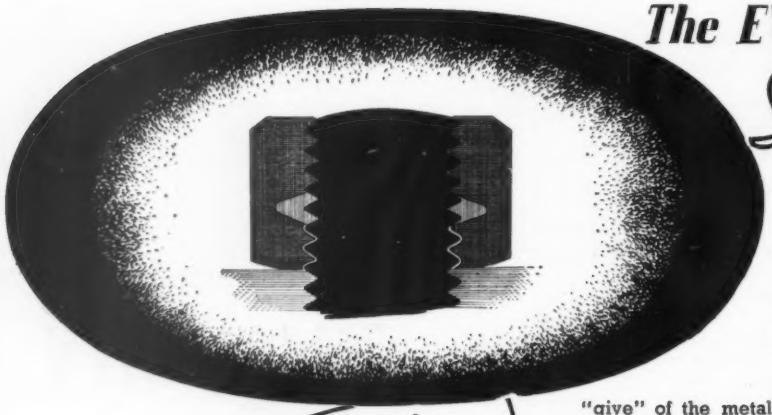

Obviously—resistance to vibration should occur at the actual point where vibration-impact takes place—the base of the nut.

The tightening-down of the "Evertite" upon its convex base causes a slight rising, and therefore decrease in diameter—of the lower threads—such "give" of the metal being made possible by the V-shaped annular groove above them. Upon unscrewing, pressure on the lower threads is released, enabling return of thread to normal.

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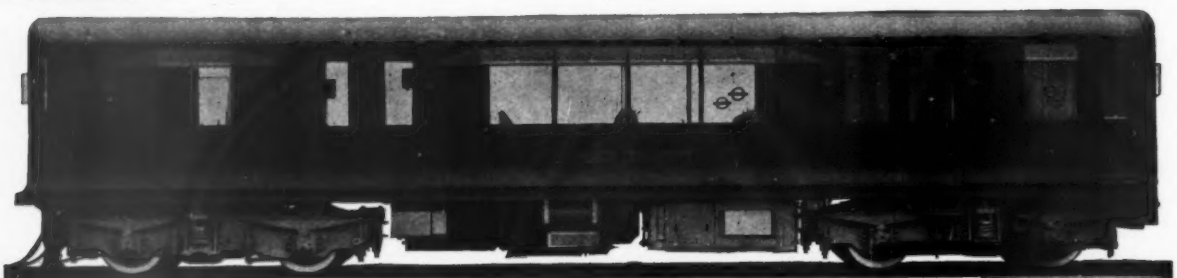

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In the January, 1940, Number is included the Annual Colonial Survey

Foreword by the Rt. Hon. MALCOLM MACDONALD, M.P.

Secretary of State for the Colonies

"I invite readers to study this Survey with close interest."

BRITISH DEPENDENCIES OVERSEAS

A series of Articles specially contributed by Governors and other leading authorities describing recent developments and the situation in the Colonies, Protectorates, Mandated Territories, etc., including the following:—

Changes in the Economic Life of Kenya.
More varied production making for increased stability. Settlement schemes to proceed.
By Major C. H. DALE, C.M.G., O.B.E., Commissioner, H.M. Eastern African Dependencies Office in London.

Achievements of Uganda in Peace and War.
Protectorate striving to make utmost contribution to Empire's effort in the economic sphere.
By MAX NUROCK, O.B.E., Acting Deputy Chief Secretary for Uganda.

Optimism Regarding Prospects in Tanganyika.
Increase in volume and value of many exports. Development Board set up.
(Specially contributed.)

Zanzibar's Campaign to Develop Food Supplies.
State of preparedness at outbreak of war. Search for new export crops continues.
(From a Correspondent.)

Industrial Development in Northern Rhodesia.
Improved transport facilities and increased output from the Copperbelt make the Territory prosperous.
By SIR JOHN MAYBIN, K.C.M.G., Governor and Commander-in-Chief of Northern Rhodesia.

Nyasaland's Three Staples—and its Population.
Estate production supplemented by peasant farming: New crops await favourable markets.
By K. L. HALL, C.M.G., Acting Governor of Nyasaland.

Improving Somaliland Stock and Pastures.
Administration's endeavour to maintain essential services, public health, justice and contentment.
By VINCENT G. GLENDAY, C.M.G., O.B.E., Governor and Commander-in-Chief of British Somaliland.

Aden: the Colony and Protectorate in 1939.
Steps to improve health, social conditions, educational facilities and public services.
(From a Correspondent.)

War-time Prospects of Anglo-Egyptian Sudan.
Resources Board set up to develop country's economy and promote agricultural policy.
(From a Correspondent.)

Year of Continued Progress in Nigeria.
Improved outlook for staple products and measures for social and economic betterment.
(Specially contributed.)

Sources of Wealth in Gold Coast Territories.
Period of normal and encouraging development giving place to a war-time concentration of effort.
By SIR ARNOLD HODSON, K.C.M.G., Governor and Commander-in-Chief of the Gold Coast.

Improved Social Services in Sierra Leone.
Developments in labour relations, agricultural education, stock breeding, health and housing.
By SIR DOUGLAS JARDINE, K.C.M.G., O.B.E., Governor and Commander-in-Chief of Sierra Leone.

Gambia's Fortunes Dependent on Groundnuts.
Excellent quality crop but low prices. Protectorate more self-supporting in foodstuffs.
By SIR THOMAS SOUTHORN, K.C.M.G., K.B.E., Governor and Commander-in-Chief of The Gambia.

Jamaica's Agricultural and Industrial Resources.
Schemes for increased food production and land settlement and measures to better labour conditions.
(Specially contributed.)

Trinidad's 5-Year Development Programme.
Government intends to proceed with more urgent schemes after reconsidering financial aspects.
(Specially contributed.)

Barbados during Legislative Tercentenary Year.
Island dependent on sugar production. Progress in public works and social services.
By MAJOR W. H. FLINN, O.B.E., Acting Governor of Barbados.

Virgin Country Broken in the Bahamas.
Islands where visitors go to play, and remain to develop new resources.
By LT.-COL. N. G. THWAITES, C.B.E., M.V.O., M.C., Bahamas Representative in London.

Reorganisation in the Windward Islands.
Road construction, land settlement, housing and agricultural development schemes taken in hand.
(Specially contributed.)

Social and Economic Structure of Leeward Islands.
Although immediate prospects are not good, long-range measures promise greater strength.
By SIR GORDON LETHEM, K.C.M.G., Governor and Commander-in-Chief of the Leeward Islands.

Measures for Development in British Guiana.
Rice-growing, gold-mining and timber industries likely to be stimulated by the war.
By SIR JOHN WADDINGTON, K.C.M.G., Acting Governor of British Guiana.

Substantial Improvement in British Honduras.
During the past five years there has been a marked evolution in social and economic life.
By CAPTAIN M. S. METZGEN, M.B.E., Commissioner for the Stann Creek District.

Malaya's Great Contribution in Peace and War.
Raw materials, financial aid and trained man-power from country in "key" position.
By G. E. CATOR, C.M.G., Agent for Malaya in London.
Message from Sir SHENTON THOMAS, G.C.M.G., O.B.E., Governor and Commander-in-Chief, Straits Settlements, and High Commissioner for the Malay States.

Recent Progress in North Borneo Production.
Expansion in rubber exports, increased food supplies, augmented medical services, and new development works.
(Specially contributed.)

Sarawak's Sound Finances and Social Progress.
Experiment in native administration, increased educational and health services and enlarged food resources.
By J. B. ARCHER, Chief Secretary of Sarawak.

Economic Readjustments in Hong Kong.
How a duty to the Empire and a responsibility to the Chinese are being discharged by the Colony.
By SIR GEOFFRY NORTHCOTE, K.C.M.G., Governor and Commander-in-Chief of Hong Kong.

Industrial and Commercial Aims of Ceylon.
The Island seeks to develop its resources and provide for its own needs as far as possible.
By E. A. P. WIJEYERATNE, Ex-Deputy Speaker, Ceylon State Council.

Mauritius Becoming a Model Colony.
Rapid progress in social legislation and measures to develop local resources.
By CAPTAIN the HON. SIR BEDE CLIFFORD, K.C.M.G., C.B., M.V.O., Governor and Commander-in-Chief of Mauritius.

More Advantageous Situation in the Seychelles.
Large land purchase by the Government. Schemes of development now well advanced.
By SIR WALTER BUCHANAN-SMITH, C.M.G., Administrator of the Government of Seychelles.

Position of Palestine as an Exporter.
Developing communications, industries and social services: problems of citrus.
(Specially contributed.)

Sure Basis for Advances in Cyprus.
Progress in agriculture, industry, education and health bring solid achievements.
By WILLIAM D. BATTERSHILL, C.M.G., Governor and Commander-in-Chief of Cyprus.

Repercussions of War on the Life of Malta.
Although schemes of economic and social improvement must be postponed, recent advances will be held.
By GEN. SIR CHARLES BONHAM-CARTER, K.C.B., C.M.G., D.S.O., Governor and Commander-in-Chief of Malta.

Conditions in Fiji and the Western Pacific.
Expansion of pineapple canning and mining industries and development of social services.
By SIR HARRY C. LUKE, K.C.M.G., Governor and Commander-in-Chief of Fiji and High Commissioner for the Western Pacific.

Development of Falkland Islands Industries.
Need to provide employment for 100 workers during greater part of the year.

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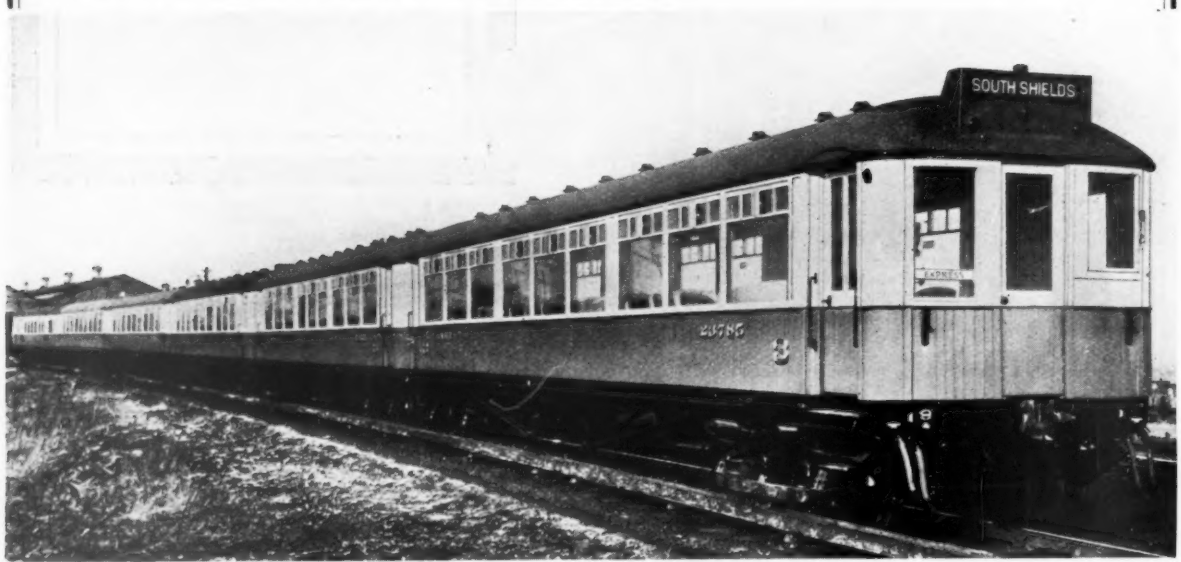

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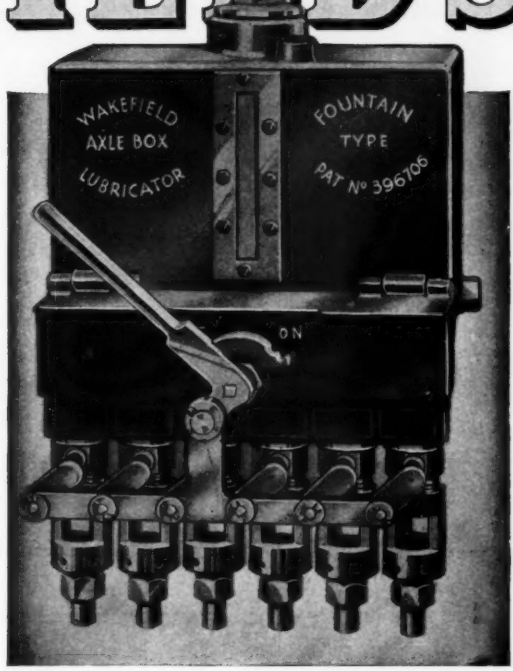

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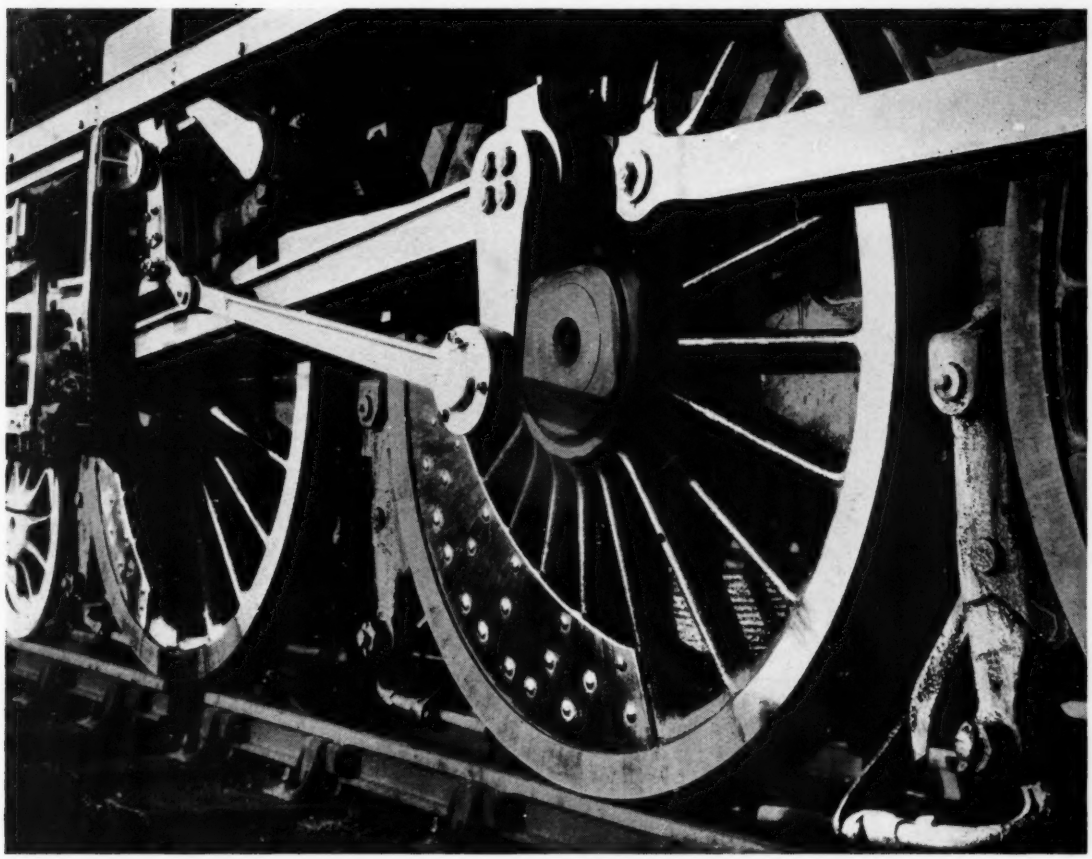

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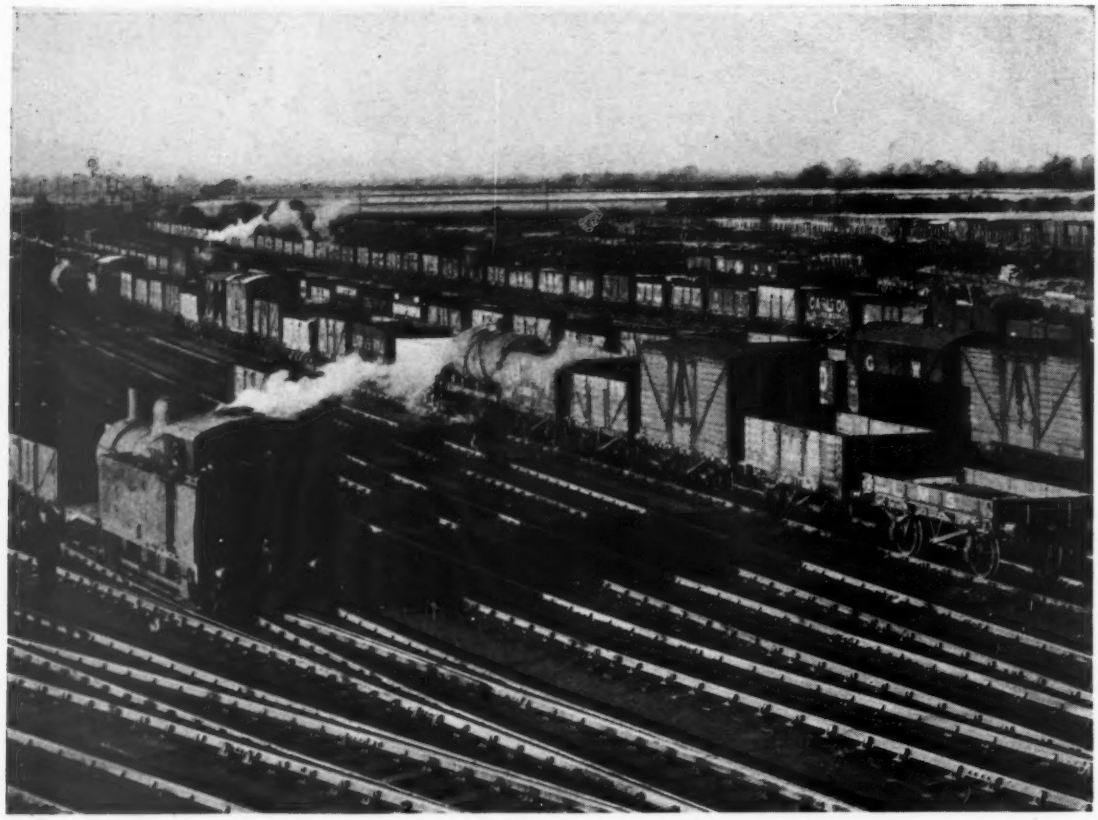

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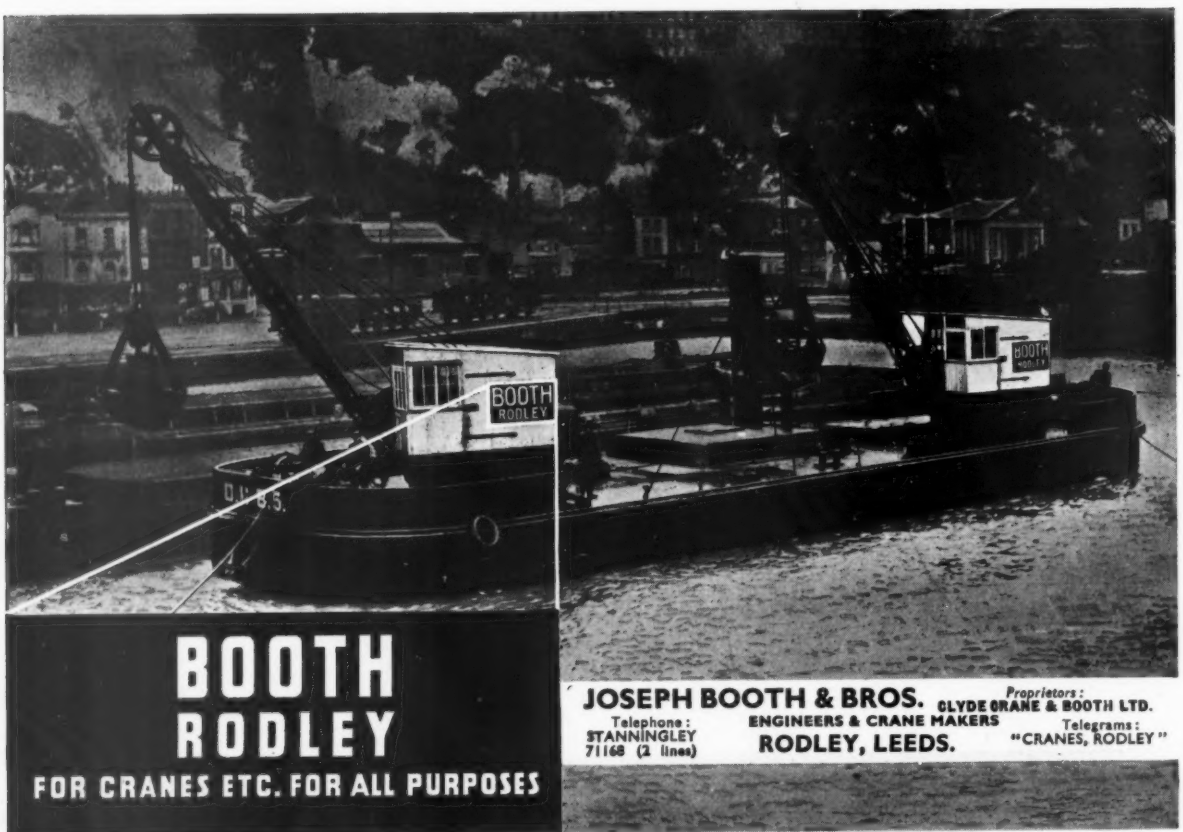

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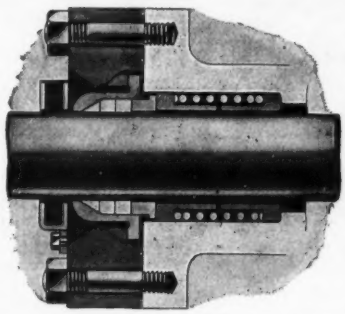

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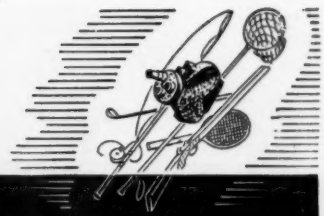

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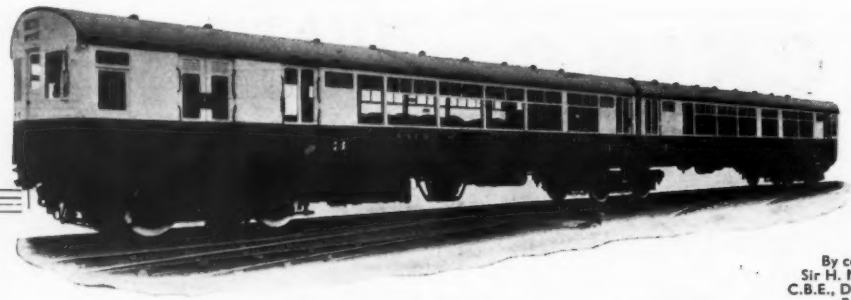

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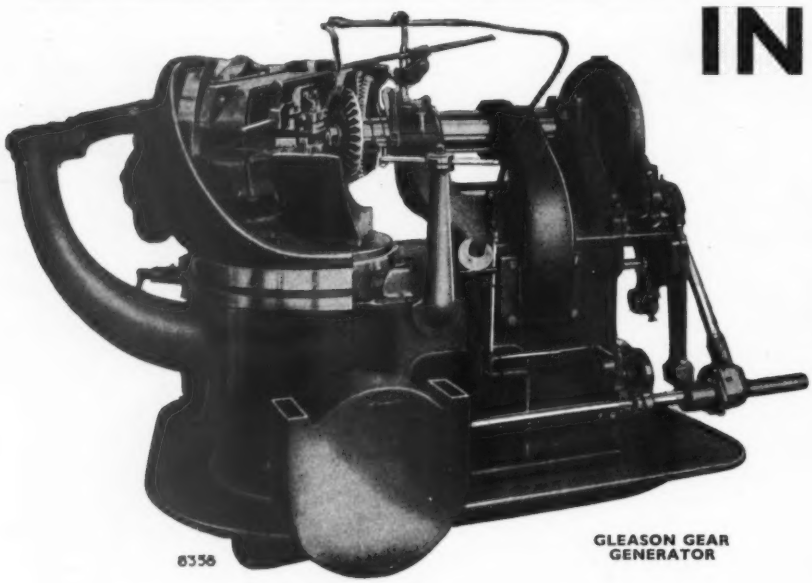

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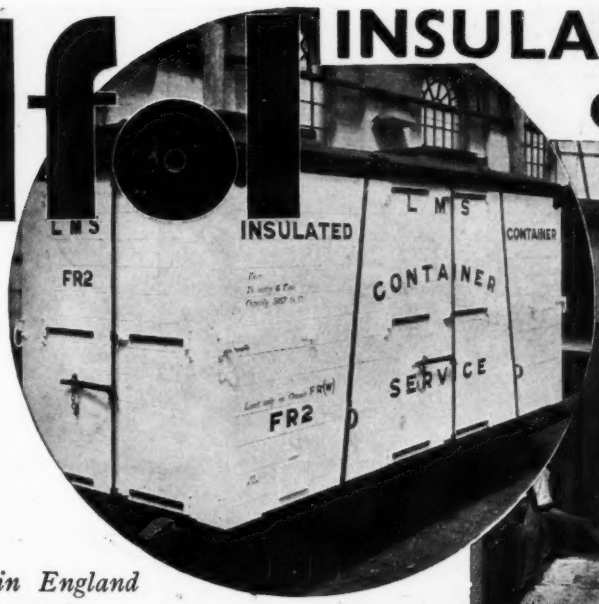

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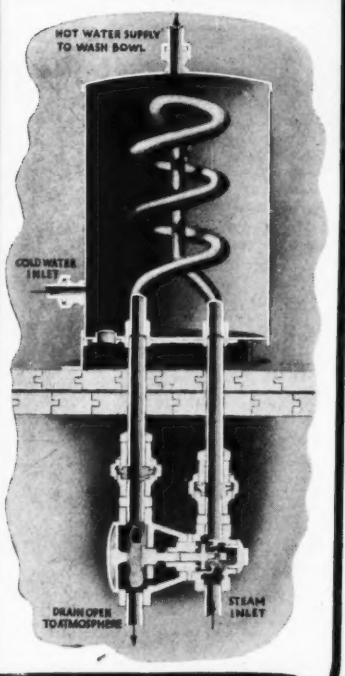

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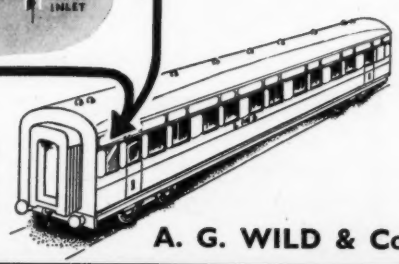

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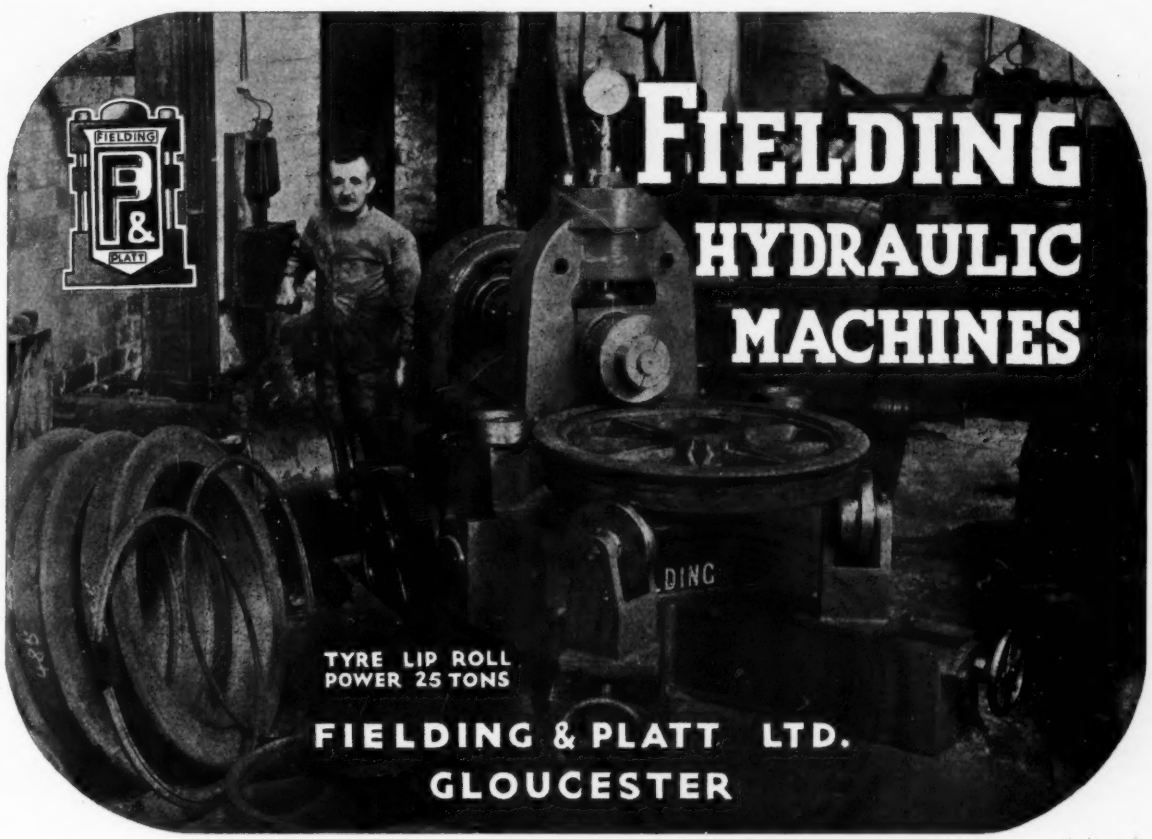
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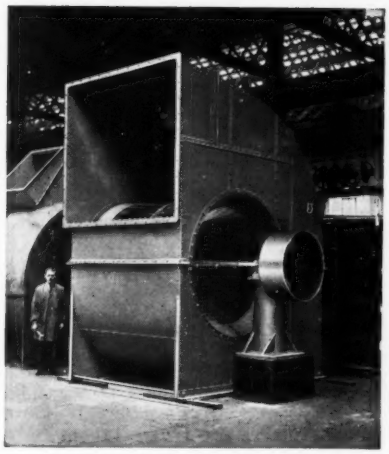

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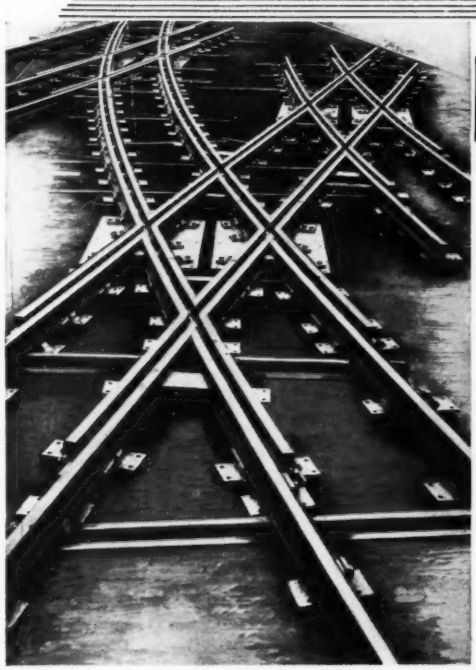

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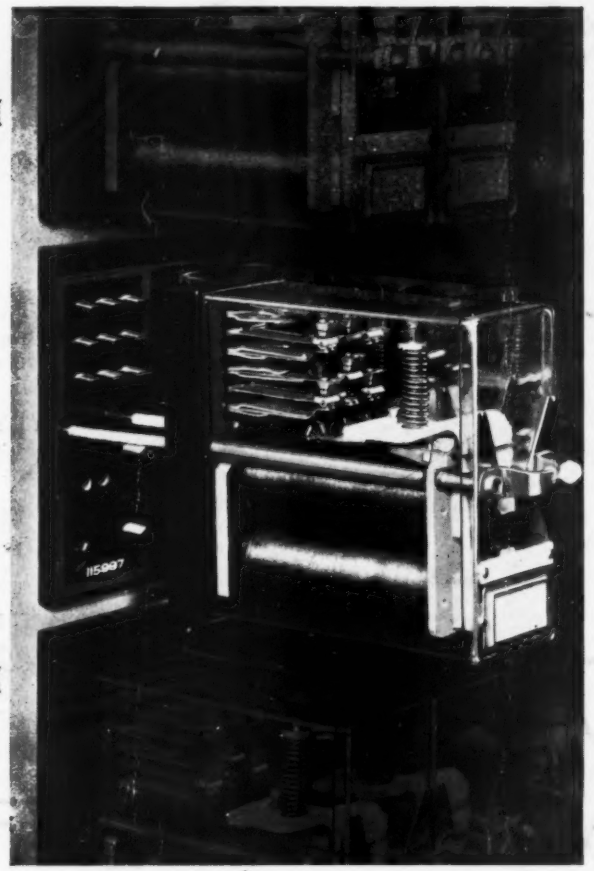

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